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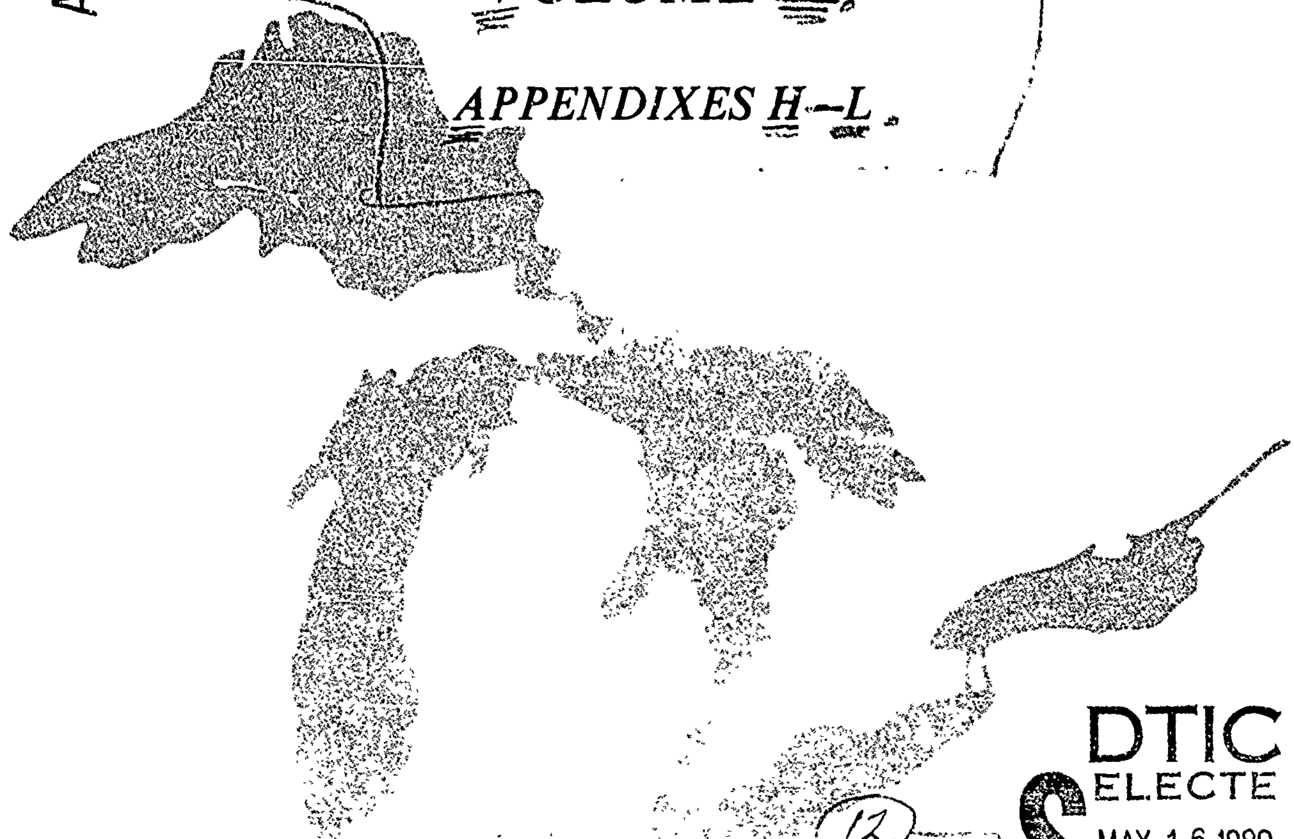
# FINAL SURVEY STUDY for GREAT LAKES and ST. LAWRENCE SEAWAY NAVIGATION SEASON EXTENSION

## VOLUME VI

### APPENDIXES H–L



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This is the Final Report for the Great Lakes and St. Lawrence Seaway Navigation Season Extension feasibility study. The goal of this study is to consider the feasibility of means of extending the navigation season on the entire system from mid-December to early April (year-round). The report uses, as a base condition, the Chief of Engineers 16 November 1977 report which recommends the extension of the navigation season on the upper four Great Lakes to 31 January (± 2 weeks). The purpose of this study is to determine whether

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Federal participation in Navigation Season Extension is desirable, and its extent, if any, to address the significant social, environmental, economic, engineering, and institutional aspects, and, to make a recommendation for Congressional consideration based on these findings.

This Final Report evaluates six proposals, considering various season lengths and geographic coverages, to further extend the navigation season on the entire Great Lakes/St. Lawrence Seaway System up to 12 months on the upper four Great Lakes, and up to 11 months on the Welland Canal, Lake Ontario and the International Section of the St. Lawrence River. This report relates U. S. costs to U. S. Benefits.

This study concludes that season extension is engineeringly and economically feasible year-round on the upper three Great Lakes, up to year-round on the St. Clair River-Lake St. Clair-Detroit River System and Lake Erie, and up to 10 months on Lake Ontario and the International Section of the St. Lawrence River. It is recognized that formal agreement with the Government of Canada is required for any extension on the system beyond the upper three Great Lakes. To assure and to confirm environmental and social feasibility of this program, an Environmental Plan of Action (EPOS) would be accomplished concurrently with implementation and execution of post-authorization planning, engineering, construction and operations with provisions to modify or stop the program if unacceptable environmental impacts surface. The District Engineer recommends that the project, as described above, be implemented.

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GREAT LAKES and ST. LAWRENCE SEAWAY

NAVIGATION SEASON EXTENSION

# APPENDIXES




AUGUST 1979

U.S. ARMY ENGINEER DISTRICT, DETROIT

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# APPENDIX H

SOCIAL ASPECTS OF A
WINTER NAVIGATION PROGRAM

AUGUST 1979

# APPENDIX H

# SOCIAL ASPECTS OF A WINTER NAVIGATION PROGRAM

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# SOCIAL ASPECTS OF A WINTER NAVIGATION PROGRAM

## INTRODUCTION

### Background

While existing Federal legislation does not prohibit system-wide winter navigation, the Great Lakes-St. Lawrence Seaway System has traditionally been forborne by shippers, generally from mid-December until early April, except for a long history of intralake winter navigation in some areas. With the closing of the system, commodities normally shipped on the waterway system are either moved by more expensive and more energy-intensive modes of transportation or are maintained in stockpiles to meet winter needs. An extended navigation season would benefit the users of commodities by providing less costly water transportation in the winter and by reducing capital investments in stockpiling and handling costs. An extended season would also result in more efficient return on the carriers' investment in the vessel fleet, greater utilization of the public investment in navigation improvements in the system, and greater access to foreign and domestic markets. These changes would have favorable impacts on the future levels of production, employment, and income in the region, as well as result in lower cost transportation. Areas of negative impact include possible environmental damage, increased shore erosion and shore structure damage in some ares, possible disruption of some recreational activities in some areas, disruption of cross channel transportation in some areas, and possible changes in the life-styles of some residents of the area.

## Methodology of Identifying Social Effects

One method used in identifying social effects of winter navigation was a literature review and file search. The inputs received at public workshops and meetings, and correspondence received as a result of public review were also significant sources of information on social effects. The details of these workshops and meetings are shown in Appendix C.

The results of this information gathering effort were examined with a "content analysis" approach, or systematic analysis of public opinion, as is appropriate to the nature of social effects, recognizing that the definition of the situation resides in the individual and his or her cultural biography [23,24]. W.I. Thomas' dictum that "situations defined as real are real in their consequences" has become a theorem in the science of Sociology [36].

Using the Thomas theorem or self-fulfilling prophecy as a framework for analyzing social phenomena, researchers focus both on the nature of a phenomenon apart from people's biased or selective perceptions of it, and the interrelationship between perceptions and qualities of a phenomenon. Applying the Thomas theorem to a social aspect of extended season: Winter navigation can disrupt seasonal recreation by weakening the ice cover near channels of vessel passage. Ice fishing, snowmobiling, cross country skiing, hunting and snowshoeing are activities which all require stable ice and makeup a large recreational market in the Great Lakes states. Investigations have found that after vessel passage people have perceived the ice unsafe when it was safe, and they have perceived it safe when it was unsafe [8,5].

This kind of approach is concerned with gathering both subjective and objective data. People's perceptions of the ice stability are subjective. Examples of objective data include: (1) the number of people participating in ice-related activities near navigational channels, (2) the amount of money they spend on their recreation, and (3) the relationship between these expenditures and employment in the recreational market. Objective data can be also borrowed from the more technical sciences as well as demography and economics. The physical distance from the navigational channel at which the ice is safe for specific recreational activities is a technical fact related to a social effect. Subjective and objective aspects of a social phenomenon are, of course, interrelated. People perceiving the ice unstable would effect the amount they spend on recreation.

The social aspects of winter navigation which were studied used this complementary subjective-objective approach. To be as exhaustive as possible, a cross check was used, based on physical proximity to winter navigation activities. This involved examining any populated or frequently used area within a given distance of winter navigation activities.

A broad, and pragmatic definition of "social effect" was used. This definition includes public concerns as well as demographic and socio-economic effects. This flexibility helps avoid duplication of other research efforts and, at the same time, insures relatively complete coverage of all possible effects.

## IDENTIFIED SOCIAL EFFECTS

The known and documented social effects of an extended winter navigation season were identified and studied under this Program. These effects include six types, occurring at various locations throughout the region. Since a single physical impact can cause differing social effects, there is some overlap among these types.

The six types of generally negative identified social effects are related to recreation, environment, oil spills, shore erosion and shore structure change, cross channel transportation and the effects on occupational groups. Underlying all of the social effects are economic considerations of labor, local business, and industry.

## Recreation

If implemented, some effects of winter navigation upon recreation would stem from the weakening of the ice cover in the channel, which could make some portions of the remaining ice cover unsafe for related activities, such as ice fishing, access to fishing sites, etc. The predominant group affected would be recreational ice fishermen [5, 15].

Disruption of the ice cover has been encountered in five harbor areas during Winter Navigation Demonstration activities [5]. These are Duluth/Superior in Minnesota; Escanaba, Saginaw Bay, and Lake St. Clair in Michigan; and Sandusky in Ohio.

On the St. Marys River, affected areas include Waiska Bay, Mosquito Bay, Brush Point, Big Point, Sugar Island on Lake Nicolet, and Raber Bay, Maud Bay, and Lake Munuscong on the Michigan shore [5, 8]. The St. Marys River, in addition to providing a channel for the passage of vessels, supports considerable sport fishing, including ice fishing which peaks in late winter. A popular area for this activity is at the north end of Neebish Island. In general, ice fishermen avoid areas of heavy vessel traffic. The winter ice surface also provides an avenue for travel by man and animals along and across the river, including snowmobiling for pleasure and transportation to fishing sites. Ice boating, though popular in the region, is rarely practiced on the river due to the natural roughness of the ice surface. Animals which may traverse the ice include such recreationally valuable species as moose, deer, and bobcat.

Considerable ice fishing takes place immediately south of the vessel track in the St. Marys River, above the Sault Ste. Marie Locks complex, between Big Point and the mouth of the Waiska River. The largest concentration of ice fishermen is in the easterly portions of Mosquito Bay and Waiska Bay. A few ice shanties have been located within 100 yards of vessel tracks [5].

Along the St. Lawrence River, four major activity centers have been identified: Cape Vincent, Wellesley Island, Chippewa Bay, and Coles Creek [15]. The winter ice cover usually forms first along the south shore canal between Montreal and Lake St. Louis in mid-December and advances toward Lake Ontario by late January. Mid-winter conditions usually produce fast ice, which is not generally affected by wind or current. Ice thickness in channel sections may average two or three feet, while lake and river ice may only reach two feet. Certain sections of the St. Lawrence River are susceptible to ice jams.

Three studies have been completed on the effects of weakened ice cover on recreation. The first study [5] identified harbor areas where winter navigation was likely to affect recreational activities and recommended further study of these areas. A second study [8] surveyed winter recreationalists along the St. Marys River and identified a "significant minority" of negative responses regarding winter navigation and recreation. The main concerns cited were unsafe (at least perceived to be unsafe) ice, muddy water, and limited movement. The winter of the study (1974-75) was particularly mild. A third study dealing with the St. Lawrence River [15] concluded that ice fishing was a major form of recreation for people living close to the areas. Because of their relatively small numbers, however, such activities do not seem to be a major economic stimulant in the area. It was further concluded that the weakening of the ice cover from ice breaking would not affect embayments, where most ice fishing takes place.

In order to integrate the previous studies, and to further quantify the regional and community impact of the possible disruption of winter recreation activities located adjacent to proposed winter navigation activity, additional and more detailed recreational studies are proposed for the pre-construction stages.

The criteria for establishing the magnitude of winter recreation near extended season navigation routes would be based on (1) the distance traveled to the site, (2) the number of people participating in recreational activities at the sites, (3) the amount of money spent by recreators, and (4) the interests served by their activities. Sites with a comparable alternative location available in the immediate vicinity would be excluded from the study, providing that the alternate location would not be affected by extended season activity.

The results of these studies would be presented on maps that would present the size of the winter recreation industry at each site, the comparative magnitude of possible alternative sites in the same vicinity, and the annual recreation expediture of the overall eight state region. Data from existing sources would be used wherever possible. If extended season is found to reduce winter recreation expenditures at any given site, these quantifiable negative impacts would be included in the benefit-cost computations and decision analysis during the stage of advanced studies.

Environment

This section is concerned with the relationship between cultural values and the environment; a more detailed treatment of the overall ecosystem is discussed in Appendix F. Many people have expressed a

concern that winter navigation may further disrupt recreation by adversely effecting the fish and wildlife which attract recreationists. Some have expressed that the implementation of winter navigation, as well as other technologically based ventures, might lead future generations to a manipulative view of man's relation to nature rather than the "traditional" one of compatibility and co-existence. Some have criticized the Government for neglecting extensive environmental baseline studies of the ecosystem before the Demonstration Program to maintain an ecological balance [39, Appendix C]. The ecosystem is certainly complex. With or without the influence of humans, nature will continue in a constant state of change and development.

## Oil Spills

Vessel spills of oil or other hazardous material are another concern, particularly for those members of the public whose livelihoods depend on recreation and tourism. Their perception of this problem is at odds with what has been learned and documented over the past several years by those who have participated in winter navigation. The assumption that vessel operation in ice is inherently more hazardous than in open water creating greater risks of oil spills underlies many of the statements made at public workshops. Some have asked who will pay the costs of such spills [39]. Appendixes B and F contain a detailed treatment of the technical aspects of oil tanker travel through ice. Some of that treatment which addresses the above concerns will be repeated here.

A ship generally leaks oil from damages incurred by severe wave action, through collisions with other vessels, or by running aground. Ice covers significantly reduce wave action. A vessel operating in ice is less likely to collide with another vessel or run aground;

because a ship can more easily be braked and stopped when it is surrounded by ice. There are fewer vessels traveling during the winter and they are traveling in established tracks at reduced speeds. Modern lake vessels are designed with double skin construction, and fuel tanks carefully located to avoid spills. The risk of an oil spill may be reduced during winter. Petroleum products have been delivered to the central lakes area during winter months for decades without an environmentally damaging incident. Spokesmen from Detroit Edison, a principal shipper of petroleum products, claim that moving the products by train would require more than ten times the fuel as by water, and these costs would be passed on to customers.

The U.S. Coast Guard has developed a number of excellent contingency plans for spill clean-up and containment. Response time has been reduced to a few hours and good equipment is available. However, based on comments received on the Draft Report, Environmental Impact Statement, and the numerous public workshops and meetings, it appears that the public and agencies with the primary mission of protecting natural resources strongly desire further improvement of the ability to handle oil or toxic material spills. These agencies and the public have highlighted potential problems and the situation dictates that technology, contingency plans and the equipment continue to be improved to afford better protection for water quality and fish and wildlife resources which are essential to the health and economic well-being of much of the population of the Great Lakes Basin. These resources form the basis of a multi-billion dollar tourist and recreation industry. Therefore, continued improvement of technology, technology transfer contingency plans and equipment is warranted and is proposed under the Environmental Plan of Action tc afford the level of protection desired by the public.

## Shore Erosion and Shore Structure Damage

Another type of winter navigation effect involves increased shoreline erosion and shore structure damage (primary docks). This effect involves riparian property owners and has developed into a significant social conern. Shore erosion may result, in part, from broken pack ice moving in a restricted channel. In areas of shallow water along the shoreline, however, the indications are that the water freezes solid to the bottom, sometimes eliminating shore erosion altogether.

Areas of deep, near-shore water may be subject to erosion due to moving ice floes, as well as from the drawdown effects of passing vessels. Drift or pack ice, as well as stable ice, has a natural effect on shore structures. Pack ice, because of the tremendous pressures generated by its movement, is capable of destroying shore structures, particularly those made of wood. Stable ice has a tendency to adhere to vertical piles and piers. Fluctuations of the water underneath the ice cover can lift these structures out of position (ice jacking).

Particularly in the connecting channels the action of passing ships will also contribute, under certain circumstances, to shore structure damage by intensifying these effects. The more restrictive a channel is the greater potential for damaging effects through alterations of water surface elevation and velocity, magnitude, and direction. Rapid water level changes may occur with ship passage.

Locations where this effect could be increased and intensified by winter navigation include the previously mentioned areas on the St. Marys River (Waiska Bay, Mosquito Bay, Brush Point, Big Point, Sugar Island on Lake Nicolet, Raber Bay, Maud Bay and Lake Munuscong on the Michigan shore), selected sites along the St. Clair-Detroit Rivers,

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Course 5 of the West Neebish Channel has been identified as a potential problem erosion and damage area. Currently, however, the West Neebish Channel is not used for winter navigation and these "natural" problems are not aggravated by winter navigation activities.

Along the Middle Neebish Channel, Course 6, the shorelines of both Sugar Island and Neebish Island are generally marshy, except for a short reach on Neebish Island. A dike about 6,000 feet long is located on the Sugar Island side of Course 6, beginning at its upstream end. Some erosion is evident along Neebish Island midway along the course.

Along Courses 8 and 9 of the Middle Neebish Channel, both bank erosion and structural damage are evident. The Neebish Island shoreline along these reaches is well-developed with a substantial number of docking facilities located between Mirre Point and Johnson Point. Some of the docks are heavily constructed, but many are not.

In the St. Clair River, the banks in the upper reaches are higher than in the lower. High water levels could inundate the low banks found in these latter reaches. Marshes and very low relief are characteristic of the shoreline of the St. Clair delta region.

Structural damages in the St. Clair River occur largely in the slower flowing delta section, where floe ice tends to build up after moving through the swifter flowing section upstream. These areas were at one time low-lying and marshy. Many have been artificially filled and bulkheaded to create residential property. This is most common from Point aux Chenes to Pearl Beach and at Harsens Island. Many small boat docks, piers, mooring facilities, and related services are located along these shoreline reaches.

In the St. Lawrence River, a preliminary study of shore structure damage and shoreline erosion has been conducted [33]. The purpose of this study was to gather and analyze baseline data which would aid in determining what effects extended winter navigation could have on shore structures and shoreline erosion, with particular attention to areas of recreational activity. The study identified those areas most likely to be affected by winter navigation, as well as identifying areas requiring further study to determine which mitigative measures are appropriate.

The study revealed that approximately 29 miles of the shoreline of the U.S. portion of the St. Lawrence River has the potential to be affected by winter navigation. This area is primarily in the downstream portion of the river and represents 5.5 percent of the shoreline investigated. Over three hundred shore structures that could be affected by season extension were also identified.

Solutions considered most promising in dealing with shoreline erosion and shore structure damage are rubble wall shore protection and pile clusters [22]. Specifically, shore protection along critically eroding riverbank locations on the St. Marys River would be provided through the placement of riprap. One mode of protection from ice for small structures protruding into the St. Marys and St. Clair-Detroit Rivers could be installation of pile clusters. Pile clusters stabilize the ice cover that usually forms in the quiet waters near shore. Suitably placed pile clusters (just beyond the furthest extending shore structure) cause a shear line to develop between consecutive pile clusters, rather than at the end of the shore structures, thus protecting these structures from the forces generated by floe ice moving down river. These measures could result in an overall improvement in the quality of shoreline and shore structures by preventing naturally occurring ice damage as well as winter navigation-related damage, thereby mitigating social consequences.

A more extensive treatment of protective structures along with a discussion of the compensation mechanisms for damages to shoreline and shore structures attributable to extended season navigation is contained in Appendix B "Formulation of Detailed Plans." The technical information on protective structures listed below indicates the research undertaken to preserve the aesthetic appeal of riparian property as well as to prevent its erosion.

Protective structures will be built in accordance with the shoreline. For example, the structural solutions recommended for the St. Marys River use rocks or boulders. Riprap structures may suffice along less developed shorelines, but more durable structures are proposed where the shoreline is close to the channel since ship-induced effects could be greater. A rubble wall or gabion blanket is usually proposed for a site with fine-grained beaches. A gabion basket is more appropriate for sites with coarser beaches. More durable structures may be considered where ice is usually stable or shorefast. Proposed new structures would have to be compatible with "neighboring" protection structures. The new structures would be adequately secured at the ends to insure that the structures are protected against flanking.

The construction of these structural solutions would constitute protective measures preventing shoreline property damage and erosion. These measures, combined with enforcement of vessel speed control and regulation of vessel routes and movement through unstable ice fields, would provide protection for riparian property.

A discussion of the compensation mechanisms for damages to shoreline and shore structures attributable to extended season navigation is contained in Appendix B, "Formulation of Detailed Plans."

Cross Channel Transportation

If it were implemented, effects of extended season navigation on the cross channel transportation systems used by island residents would stem from two sources: broken ice clogging ferry docks and disrupting service, and the maintenance of an open channel preventing cross channel transportation over the ice cover. Any interruption in transportation constitutes a major inconvenience to the residents of islands since it requires altering their established means of access to the mainland. Each is discussed below.

## Ferries

Winter navigation ice breaking activities disrupt the stable ice cover and can increase the frequency of broken ice clogging the ferry landings and interrupting service. Residents potentially subject to this type of transportation service interruption are living on Sugar Island in the St. Marys River, and the ferry crossings along the St. Clair River (St. Clair - Courtright, Roberts Landing - Port Lambton, Marine City - Sombra, Algonac - Walpole Island, and the Harsens Island ferry). Also Drummond Island residents, in the St. Marys River, claim that winter navigation disrupts the island transportation service between the island and the mainland.

The winter navigation-related transportation problems of the islands of the St. Marys River are each different and must be examined separately. Sugar Island is approximately 15 miles long with a maximum width of 8 1/2 miles. The island has about 450 permanent residents. Travel to and from is by a ferry with a capacity of twelve automobiles. During the winter season the ferry transports about 60 automobiles per day. In addition, the ferry transports school buses, for about 50 children attending schools on the mainland, and trucks supplying provisions and fuel oil to the island. Most of the means of solving this problem have been recommended in the March 1976 Interim Survey Report.

During the summer, the ferry landing is clear and there are no obstructions to passage between the island and the mainland. In winter, however, ice conditions present a problem, aggravated by winter navigation. When either the ferry landing becomes choked with ice or ice builds up in the mainland ferry slip, the ferry is unable to operate. A strong cross current on the island side normally keeps the island slip clear of ice. On the mainland side, there is no such cross current and drift ice entering the slip can make landing difficult or impossible. The ferry landing itself can also become choked with ice, which can prevent the ferry from operating. The amount of drifting ice entering this portion of the river depends, in part, on the stability of the ice cover in Soo Harbor which, in turn, is influenced by four factors: (1) warm water discharges from the Sault Ste. Marie sewage outfall eroding the ice along the shoreline, (2) the Sault Edison hydroelectric plant discharge causing turbulence which erodes harbor ice, (3) vessel operations to and from the U.S. Coast Guard harbor base breaking up the ice, and (4) steel and paper mills in the area adding thermal input to the harbor waters which tends to suppress stable ice formation. Winter navigation-related icebreaking has added to these factors. In order to prevent these factors from combining to cause major problems for the ferry, a bubbler flusher was installed at the ferry dock on the mainland side and an ice boom was installed near the Sugar Island ferry slip in 1975 and subsequent years. The ice boom is successful in forming a stable ice cover upstream in the harbor area, and the bubbler has prevented ice from impeding the ferry from docking. Both have resulted in ferry service being more dependable than under natural, pre-season extension activities.

Neebish Island is about four miles long and two miles wide and is located between Sugar and Lime Islands. It is bounded on the Canadian side by the Middle Neebish Channel and on the American side by the West Neebish Channel. The West Neebish Channel is about 9,000

feet long and 300 feet wide. Island access is through a ferry to the U.S. mainland. The island is "thinly settled" in winter with a year-round population of 30 to 50 individuals. Winter navigation activities would be confined to the Middle Neebish Channel and would not disrupt ferry service. If the West Neebish Channel were to be used for winter navigation, cross channel transportation would be disrupted.

Drummond Island is located about nine miles downstream from Lime Island and is about 21 miles long and 12 miles wide. It is separated from mainland Michigan by DeTour Passage, a distance of about one mile. The island supports the Drummond Dolomite Quarry and summer recreational facilities, as well as a year-round population of about 600. A ferry operates across DeTour Passage year-round. Winter navigation would interfere with an alternate mode route over the ice cover around Pipe Island. Winter ferry service is naturally and periodically made difficult by occasional heavy ice conditions resulting from winds driving Lake Huron ice into the passage area. Loose ice can be dislodged at the edge of the ferry track which may add to the difficulties of ferry operations. The county government contends that ferry service difficulties are also aggravated by additional ice and thicker ice flowing into the area due to season extension. This has not been substantiated by investigations to date. However, further investigations are apparently necessary and proposed to determine the percentage of ferry costs--first cost and maintenance--that should be attributed to normal navigation, non-season extension winter operations, and those of season extension. This would be accomplished in the General Design Memorandum stage and compensation recommended, if appropriate.

The ferry service disruptions along the St. Clair River are similar and can be described as a single phenomenon. Briefly, the ferry service would be interrupted when the ferry landing becomes choked with ice or when ice builds up in the ferry slips preventing the docking of the ferry. The St. Clair River does not develop a solid ice cover. The ice causing the interruptions enters the system at the head of the St. Clair River when the natural ice bridge there collapses. Winter navigation would contribute to occasional collapse of this natural ice bridge, aggravating the ice situation at ferry landings downstream.

Moving from the problem stage to solutions, and starting with the St. Marys River, Sugar Island transportation was resolved during the demonstration program by ferry modification to increase its ice operating capability, an ice navigation boom, ice stabilization islands, and the installation of an air bubbler/flusher system at the mainland dock [22].

Since this report recommends utilizing the Middle Neebish Channel for the winter navigation season, no additional actions are proposed, as island access would be the same as in the traditional season, across the West Neebish Channel.

For Drummond Island, further investigations are proposed, as previously discussed. As further assurance that the impact on island transportation is minimized, contingency plans for Sugar, Neebish, Lime, and Drummond Islands in the St. Marys are proposed. These plans address back-up transportation measures and are presented in detail in Appendix B. Additionally, an all-weather backup vehicle to service all four crossings, operated by the Eastern Upper Peninsula Transportation Authority, has been considered but is not proposed. It would be further considered during the advanced engineering and design phase.

One of the solutions recommended for the St. Clair River to help manage ice and prevent jams is an ice control structure at the head of the St. Clair River. This ice control structure should all but eliminate winter navigation endangered ferry problems. However, because of its position at the mouth of the Middle and North Channels, Harsens Island and its associated ferry deserve special mention. A study similar to that mentioned for Drummond Island would be accomplished during the General Design Memorandum stage to determine the share of cost attributable to season extension. Solutions with appropriate cost sharing would be recommended, if appropriate.

## Open Channels

The second source of transportation effects from winter navigation would be the disruption of cross channel pedestrian and vehicle traffic through the maintenance of vessel tracks in the ice cover. Drummond Island's alternate route, Lime Island in the St. Marys River, and the area around Grindstone Island in the St. Lawrence River would be subject to this effect.

Lime Island, located about 35 miles downstream from Sault Ste. Marie, is separated from the mainland by three miles of water. The principal activity on this U.S. island is the operation of a fueling station for the freighters which stop for fuel at the Lime Island dock. Approximately seven operators of the fueling dock and their families live on the island. Transportation to and from Lime Island is provided by a small power boat during the regular navigation season, before the formation of heavy ice, and by foot or snowmobile after the ice has formed. Prior to extended season navigation under the Demonstration Program, the small boat could travel until the end of the navigation season. There was only a short time between the passing of the last commercial vessel and the ice cover reaching

sufficient thickness to safely carry pedestrians and snowmobiles. Thus, the island residents were without access to the mainland for only a short time. When the Demonstration Program for extended season navigation was implemented, however, the vessel track broken in the ice cover prevented foot or snowmobile travel. During these periods the islanders are unable to get supplies, receive mail, or reach the mainland.

The recommended solutions for the Lime Island transportation problem are an air boat, with an alternate snowmobile route to Drummond Island. A demonstration air boat was funded through the Demonstration Program. Although the air boat was first accepted, dissatisfaction with it has increased over the years. Its original design has been improved. A new and better vehicle is being recommended in the March 1976 Interim Survey Report.

In the St. Lawrence River area a preliminary study has been conducted by the St. Lawrence Seaway Development Corporation to identify the extent to which year-round navigation could affect cross channel travel by permanent residents of the islands in the international section of the river [32]. This study identified the islands occupied by year-round residents, existing modes of cross channel travel, purpose and fequency of travel, time and distance of trips, and methods of mitigating the adverse effects identified.

In the St. Lawrence, winter vessel movement would complicate transportation problems for the 71 year-round residents of Grindstone Island, in that their ice bridge direct to the Village of Clayton would be disrupted. During winter, most of the residents do not hold jobs on the mainland. However, they must be able to cross daily, being available for work to qualify for unemployment insurance. During the 1978-79 school year, thirteen children from

Grindstone Island attended school in Clayton. They crossed twice weekly, on Monday and Friday, and boarded in Clayton during the week. The children are transported on a power punt by the only island resident licensed to operate such a vehicle. The same resident delivers mail to the other permanent winter island inhabitants. Four other residents own power punts which may be used for emergency travel and shopping since provisions are available only on the mainland [37].

During the advanced stages of the study of Season Extension, studies would be made to determine engineeringly and socially feasible means of transportation between Clayton and Grindstone Island. A socially feasible means of transportation would preserve the private lifestyle of islanders. One possibility would be that residents would travel to Wellesley Island by power punt and from this island drive to Clayton. This solution would not be socially feasible, because many Grindstone Islanders do not own cars and can currently maintain their livelihoods without them. Providing a tug with icebreaking capability, associated launching-landing ramps and a maintenance building, is the currently proposed solution for continuing winter access directly between Grindstone Island and Clayton, New York. An on-site operator for the vehicle would also be a requirement.

Occupational Groups

A "Sociological Assessment Survey" of four occupational groups has been conducted. These groups include: vessel personnel, terminal personnel, lock personnel, and pilot personnel. The effects on these groups are basically of two types: individual safety and comfort, and the "psychosocial" effects of extended season operation, such as morale and familial relations [14]. Discussion which follows, is by occupational group.

## Vessel Personnel and Pilots

The vessel personnel group consists of about 5,000 individuals at the height of the summer shipping season. These employees are hired by shipping companies serving the Great Lakes and then assigned to vessels operated by crews of about 30 men each. This group would be most affected by an extended navigation season primarily because these workers do not go home at the end of each working day, but are aboard ship around the clock for the entire trip.

A similarly affected group is the vessel pilots. U.S. and Canadian pilot personnel number about 155 throughout the system. The increased risks to pilots and vessel personnel are perceived as threefold. First, the survival time of an individual overboard is greatly reduced in the winter. Second, the weather itself may make location and rescue more difficult. Third, the risk of accidents, either individual or vessel, may be increased. Related to all of these is the impaired performance of certain equipment during winter operation.

An additional effect on these two groups is the change from seasonal employment to year-round employment, and the effect this may have on their families and life styles. Specifically, these individuals would no longer be unemployed during the winter months, which would modify some traditional vacations. Claims for unemployment compensation would also be reduced or eliminated for some individuals basing their claim on seasonal unemployment.

## Terminal and Lock Personnel

Terminal personnel numbers about 4,000 individuals at the peak of the summer season. Terminal personnel would be employed by each winter port on the Great Lakes. A similar group, lock personnel,

numbers about 175 at the Sault Ste. Marie locks and about 175 at the two U.S. St. Lawrence Seaway Locks [14]. Terminal and lock personnel are usually employed year-round and season extension would not materially affect their work status, though their specific duties during winter might change. The primary effect on these groups would be increased exposure to extreme weather and the additional risk posed by ice and snow accumulations on docks and other work areas.

The employment projection presented in Appendix D indicates that navigation season extension would improve employment in the shipping industry at participating ports, increasing the present number of longshoremen, stevedore and terminal operators by about 50 percent, merchant seamen by about 20 percent, and ship and equipment repair personnel by about 15 percent. Vessel personnel have decreased on the Great Lakes with the use of fewer and larger ships independently from season extension. For example, 6,242 vessel personnel were employed at the height of the summer season 1 July 1973; 5,440 were employed on 1 July 1975 [14]. Navigation season extension would encourage the better utilization of the existing Great Lakes fleet and could increase job opportunities for those seeking winter work. Overall employment opportunities could, therefore, improve for vessel personnel. Employment opportunities of other occupational groups less directly affected by extended season, would require more in-depth studies.

Based on the results of this exploratory survey, recommendations were made for better information dissemination to affected personnel, for the use of volunteers where possible, and for more personnel involvement and feedback. More summer vacation time is recommended for seasonal personnel working the extended season.

Other solutions to these problems to be considered if season extension is implemented are the provision of improved cold weather

gear for lock and terminal personnel, ice and snow removal, safety lines for line handlers, and contingency plans for rescue and revival. Solutions relating to vessel and pilot personnel to be considered include vessel monitoring and reporting systems, emergency position indicating radio beacons, man overboard alarms, self-launching or catapulted type enclosed life boats, water-tight bulkheads between cargo holds, top dock edges fitted with railroad type rail to prevent slipping from ice covered docks into the water, and float-off crew capsules [22].

Spokesmen from the International Shipmasters Association have stated that the Demonstration Program has ignored the problem of providing safety and comfort for vessel crews.

During the Demonstration Program, some 280 exposure suits were distributed to vessel crews participating in extended season activities. Some personnel claimed that the suits would overheat them if worn in the course of their work. After study of all exposure suits commercially available, the Coast Guard has approved two all-weather suits and one exposure jacket. They are still testing two other exposure jackets. The exposure suits provide floatation and thermal insulation for all parts of the body except the face.

Life jackets are available on every major Great Lakes' fleet ship, and deck personnel wear them while working. The life jacket affords limited floatation and some thermal insulation. The estimated survival time for the average man wearing a life jacket immersed in 32° to 33° F water is about 30 minutes, but varies greatly between circumstances and individuals. Survival time as used here is defined as the median immersion time with a 50% probability of unconsciousness [41]. Every vessel also has two inflatable life

rafts with covers and open life boats. The GOTT (a newly constructed 1,000 foot vessel) has, and future vessels will have, self-launching enclosed life boats.

The Coast Guard has conducted experiments with Emergency Position Radio Beacons (EPIRBS). A "Man Overboard Detection and Location System" was developed in which each person aboard a vessel wore a radio transmitter with a self-contained antenna which would operate automatically once the wearer entered the water. A special receiver on the bridge of the vessel would sound an alarm when the signal was transmitted. The signal then could be used as a honing device to locate the person in the water. In practice sessions, using the Williamson maneuver, the man overboard was rescued and administered first aid in the boat on an average of ten minutes. A similar honing device would alert the Coast Guard and other vessels if a ship were sinking. Presently, the Federal Communications Center is working on a frequency for the EPIRBS which will not interrupt radio and television stations, airplane and other vessel transmissions. Purchase of safety/survival equipment and training personnel in its use is the continuing responsibility of the vessel owner.

## POTENTIAL AND LONG-TERM SOCIAL EFFECTS

Two other potential and long-term social effects of winter navigation were identified through public meetings and interviews. They include localized unemployment and changes in regional identities and power structures. Some concern was raised over people moving to areas for temporary construction jobs associated with winter navigation, and then becoming unemployed [39]. However, an economic analysis indicates that direct benefits to local ports, transportation and winter rate savings are likely to add permanent employment to the region [40]. These benefits are not calculated in the overall benefit/cost ratio; because, trade from other areas of

the country will be diverted to the Great Lakes. According to economic projections, the Great Lakes will employ a smaller proportion of the working force and have a lower per capita income in relation to other regions by 2020. Winter navigation, if implemented, might help to positively alter these projections. Federal contracts in local areas may tend to alter regional identities and power structures [39]. These long range concerns are only potential, because, all effected local areas have yet to be identified. Social perceptions are further depicted in Appendix C.

These potential effects of winter navigation need to be monitored on a region-wide basis. Therefore, a demographically based monitoring study is being recommended for the advanced engineering and design stage. This study would utilize a "social well-being account" methodology [7], and would monitor selected areas throughout the region to document the gross social effects of extended season operations on various types of communities and occupational groups. Results of such a monitoring program would be an integral part of future validation reports. Such a study would, as a minimum, include the effects of winter navigation upon community institutions, the socio-economic health of the area, national emergency preparedness, and the aggregate social well-being.

Archaeological, Historical and Cultural Resources

A preliminary study has been conducted to identify known archaeological, historical, and paleontological resources in the Great Lakes region which might be impacted by season extension activities. Minor impacts have been identified at some sites which may be due, in part, to navigation season extension activities. Several other sites may possibly be impacted in the future. Various site specific studies are currently being considered to fully assess the likelihood and extent of potential impacts. This preliminary study is included in its entirety in Appendix C.

CONCLUSION

In summary, six types of social effects were discussed. The public expressed concerns about recreation, the environment, oil spills, shore erosion and shore structure damage, safety to vessel personnel and cross channel transportation problems. Many involved a segment of the public defining some phenomenon related to winter navigation differently than did researchers who performed systematic investigations.

If not careful, the secondary negative consequences of winter navigation which people anticipate could tend to occur if they act on their perceptions or misperceptions rather than results directly from the extended season activities themselves. Some people who are concerned with recreation and tourism believe that winter navigation will weaken the ice cover disrupting ice related activities at sites adjacent to channels. Whether or not the ice cover is too unstable to support these activities, the recreation could be disrupted if people act on this belief.

Some naturalists and conservationists would oppose all technologically based ventures which could in any way alter the balance of the ecological system fearing that any change in the environment might harm the species they wish to hunt, fish or preserve. On the other hand, fishing and hunting, in themselves, may dwindle the supply of certain species. Scientific measures by a variety of groups may be necessary to preserve and multiply these species. Investigations may find, and hopefully will via the EPOA, that the ecosystem can support both winter navigation and fish for recreators.

Spokesmen from several agencies have expressed an assumption that the risks of an oil spill are greater when tankers travel through ice. Such an assumption is not borne out by the Demonstration Program. Supporting the lower risk thesis are other agencies, which

maintain that the risk of an oil spill is less during extended season operation than during the normal season. To prohibit winter shipping of oil during these energy short times would seem counter productive, socially and economically. The stance of "carefully moving while improving," as suggested by the EPOA and FWS, seems to strike a reasonable balance. Known methods of building structures which would preserve the natural aesthetic appeal of shorelines and protect them from erosion, and methods of insuring the safety and comfort of vessel personnel were described.

Four additional efforts are currently being recommended for the Preconstruction Phase. (1) Safe and socially feasible transportation alternatives for Grindstone Islanders, or those which would enable residents to preserve their way of life and social values, would be devised. (2) A study would be undertaken to measure the magnitude of disrupted winter recreation activities at various sites adjacent to navigational channels. (3) Sites near navigational channels with archaeological, historical and paleontological resources would be studied for means of preserving their cultural value from any possible impacts by season extension activities. (4) A social well-being account study would investigate the six types of effects previously mentioned; namely, recreation, environment, oil spills, shore erosion and shore structure change, cross channel transportation, and occupational groups, with a long term impact analysis of season extension on specific regions.

The problem of potential increased local unemployment was raised at public workshops [39]. Although the role that each local area would play in winter navigation has yet to evolve, a recent regional economic analysis [40] indicates that winter navigation would increase permanent employment opportunities in the Great Lakes Region.

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# APPENDIX I

LEVELS
AND FLOWS

AUGUST 1979

# APPENDIX I

# LEVELS AND FLOWS

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# APPENDIX I

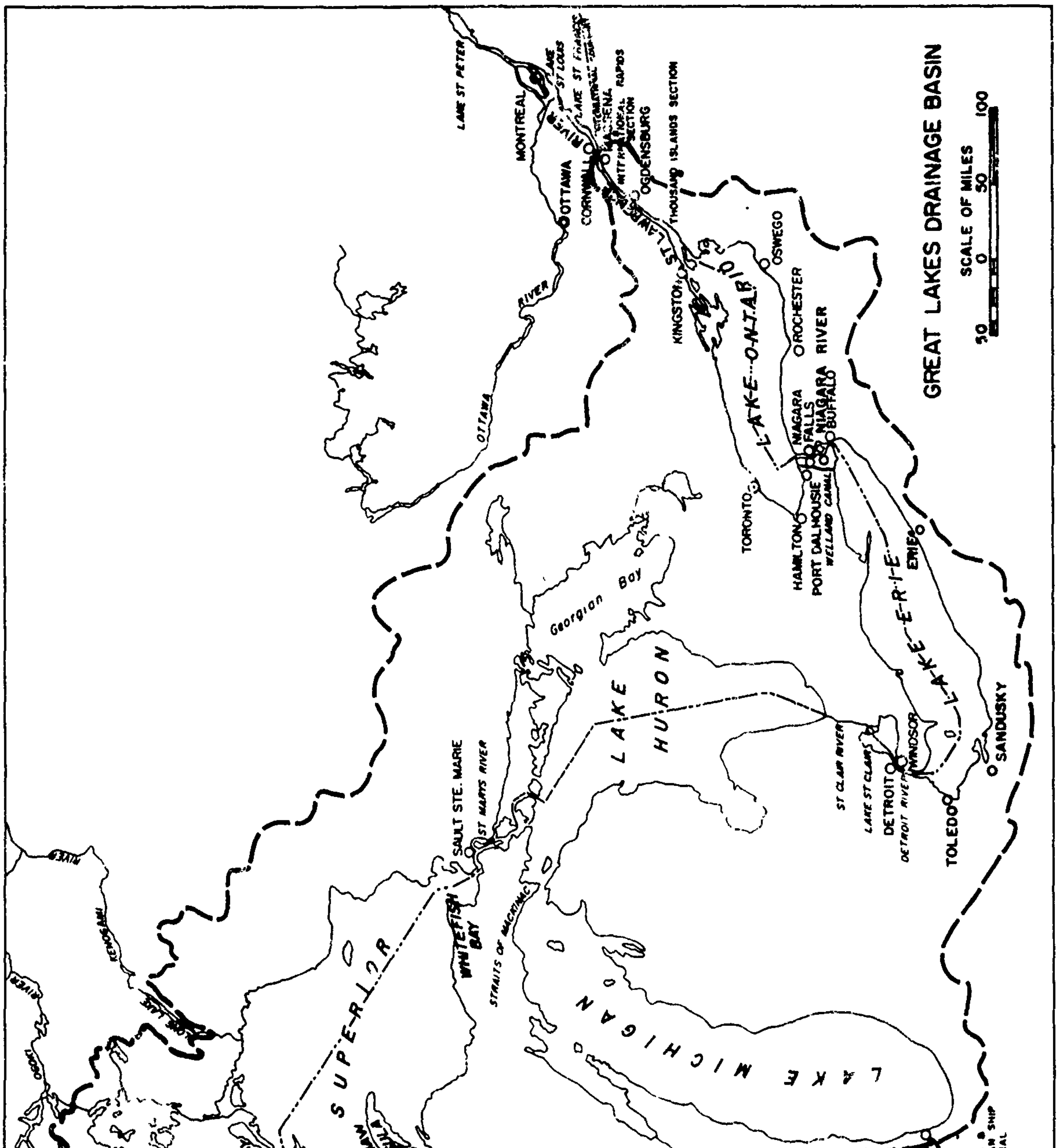
# LEVELS AND FLOWS

This Appendix describes the hydraulic characteristics of the Great Lakes-St. Lawrence system with particular emphasis on ice formation, roughness, thickness, and its effects on levels and flows. It includes a discussion of these conditions in relation to normal conditions and the possible impact that changes in these conditions (as a result of movement of vessels through the ice) may have on the levels and flows of the Great Lakes, the Connecting Channels and the St. Lawrence River.

## HYDRAULIC CHARACTERISTICS OF THE GREAT LAKES-ST. LAWRENCE SYSTEM

The Great Lakes-St. Lawrence Basin shown on Figure 1 extends from the west of Lake Superior to the Gulf of St. Lawrence on the Atlantic Ocean, a distance of more than 2,000 miles. The five Great Lakes, Superior, Michigan, Huron, Erie, and Ontario, and their connecting channels and Lake St. Clair, have a water surface of about 95,000 square miles.

In this system, the outflows from Lake Superior discharge through the St. Marys River into Lakes Michigan-Huron (which are treated as one lake because of a common water surface elevation). Outflows from Lakes Michigan-Huron flow through the St. Clair River, Lake St. Clair and the Detroit River into Lake Erie. A relatively small flow (3,200 cfs) is discharged through the Chicago Sanitary and Ship Canal into the Mississippi River Basin. From Lake Erie, the Niagara River carries the main outflow into Lake Ontario. An annual average of about 700 cfs (1,100 cfs during the navigation season) is diverted from the river at Tonawanda, New York, and passes through the New




GREAT LAKES-ST. LAWRENCE RIVER DRAINAGE SYSTEM

FIGURE 1

York State Barge Canal to Lake Ontario. In addition to this diversion, 7,000 cfs (6,500 cfs in the winter) are diverted directly from Lake Erie into the Welland Canal, Ontario, Canada. This canal is used for vessel navigation between Lake Erie and Lake Ontario.

Outflow from Lake Ontario is through the St. Lawrence River into the Gulf of St. Lawrence and the Atlantic Ocean. The flow in the International Section of the St. Lawrence River is totally controlled through a series of locks, dams, and powerhouses.

Two additional factors, other than the natural factors, which affect the levels and flows within the Great Lakes System, are the Long Lake and Ogoki Diversions. These diversions, which divert water into Lake Superior from the Albany River basin, Ontario, Canada, were started in 1939 and 1943 and increase the water supply to the System by approximately 5,000 cfs on the average.

Lake Superior

Lake Superior is the largest and deepest of the Great Lakes with an extremely large heat storage capacity. In this lake, wind, waves and currents have a more pronounced effect upon the ice cover than in the other lakes. Wind and currents produce upwelling of lake water, bringing warm water into contact with the ice, and thus cause melting of the underside of the ice cover even though air temperatures are below freezing. Upwelling currents not only change the extent but also the distribution of ice cover. The largest extent of ice cover observed until the winter of 1978-1979 on Lake Superior was approximately 95 percent and occurred at least twice during the previous 16 winters. In February 1979, the lake became 100% ice covered. The lake surface area typically can be expected to become 40 percent ice covered during a mild winter, 60 percent during

a normal winter, and 95 percent during a severe winter. The maximum pattern of ice coverage of the lake for a normal winter is shown on Figure 2. Ice thickness in excess of 3 feet in the harbors along the north shore is common.

The initial lake ice formation, other than that forming in harbors and bays, takes place along the north shore; in Duluth, Minnesota; and Apostle Islands, Wisconsin areas in the western portion of the lake. As the ice season progresses, the ice cover increases so that the entire lake perimeter becomes covered with an ice sheet extending many miles out into the lake. During mild or normal winters, the area of the Lake between Stannard Rock and Caribou Island remains ice free except for isolated areas of drift ice. The average dates of maximum accumulation of freezing degree days will vary on Lake Superior from March 30 on the southeastern shore (Marquette to Whitefish Point, Michigan) to April 10 on the north shore in the Marathon, Ontario area. Because of the season duration, ice thickness, and the textural changes which take place in the drifting floes on this most northern of the Great Lakes, the ice cover resembles and acts as an arctic ice pack.

Lake Michigan

Green Bay and Big and Little Bays de Noc in the northwest portion of Lake Michigan are the areas first to form an extensive ice cover. The Straits of Mackinac and the shallow areas to the north of Beaver Island, Michigan, are the next areas to become ice covered. The ice accumulates in a southerly direction, with a rapid build up in the relatively shallow area east of the Manitou and Fox Islands and a slower accumulation around the southern perimeter of the Lake. The unique circular current patterns of southern Lake Michigan distribute drifting floes along the shore. Even during a mild ice season, these floes can consolidate and extend from the shore out into the lake

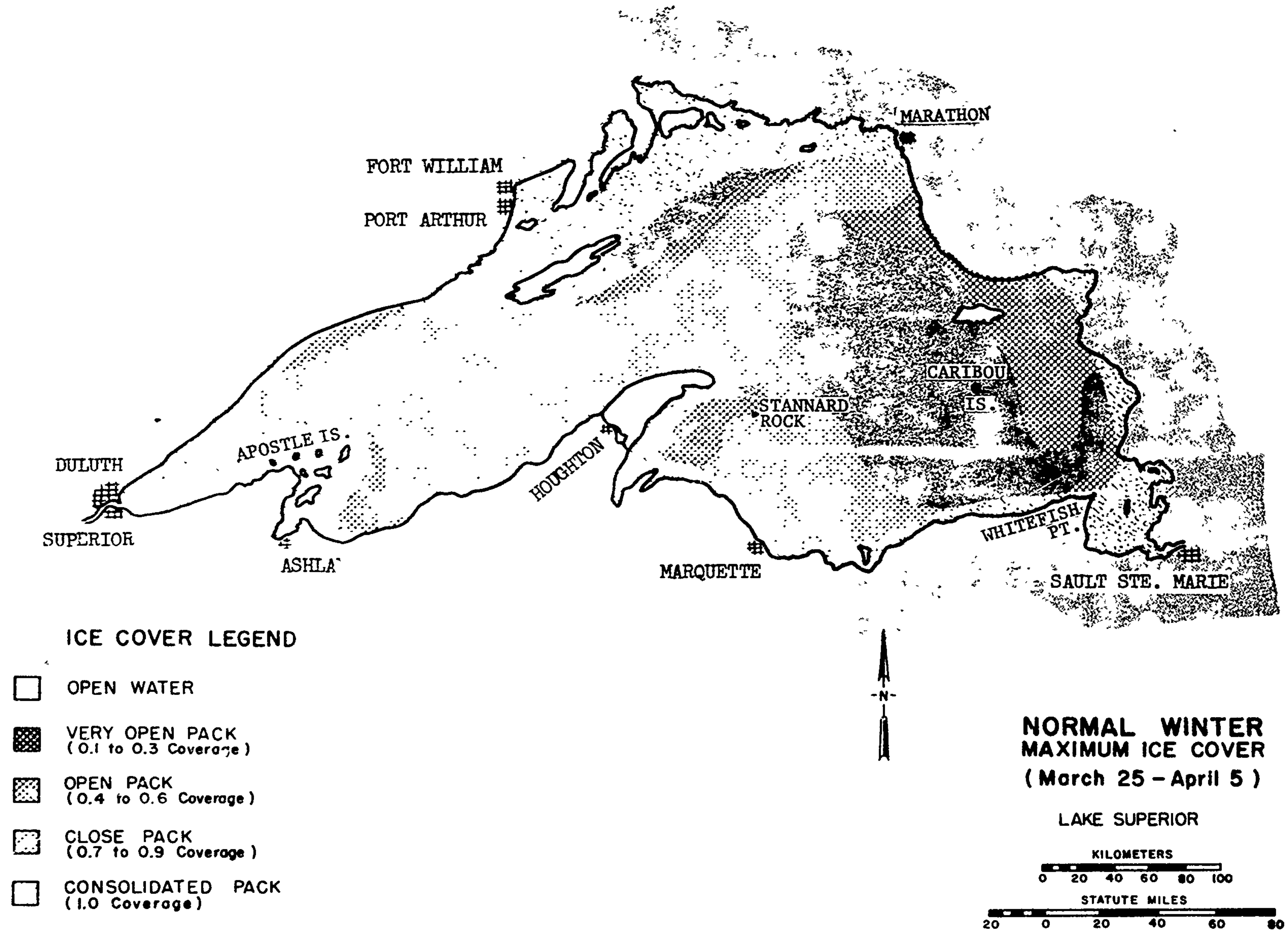

FORT WILLIAM
PORT ARTHUR
MARATHON
CARIBOU IS.
STANNARD ROCK
APOSTLE IS.
DULUTH
SUPERIOR
ASHLA
HOUGHTON
MARQUETTE
WHITEFISH PT.
SAULT STE. MARIE
-N-
ICE COVER LEGEND
OPEN WATER
VERY OPEN PACK (0.1 to 0.3 Coverage)
OPEN PACK (0.4 to 0.6 Coverage)
CLOSE PACK (0.7 to 0.9 Coverage)
CONSOLIDATED PACK (1.0 Coverage)
NORMAL WINTER
MAXIMUM ICE COVER
(March 25 – April 5)
LAKE SUPERIOR
KILOMETERS
0 20 40 60 80 100
STATUTE MILES
20 0 20 40 60 80

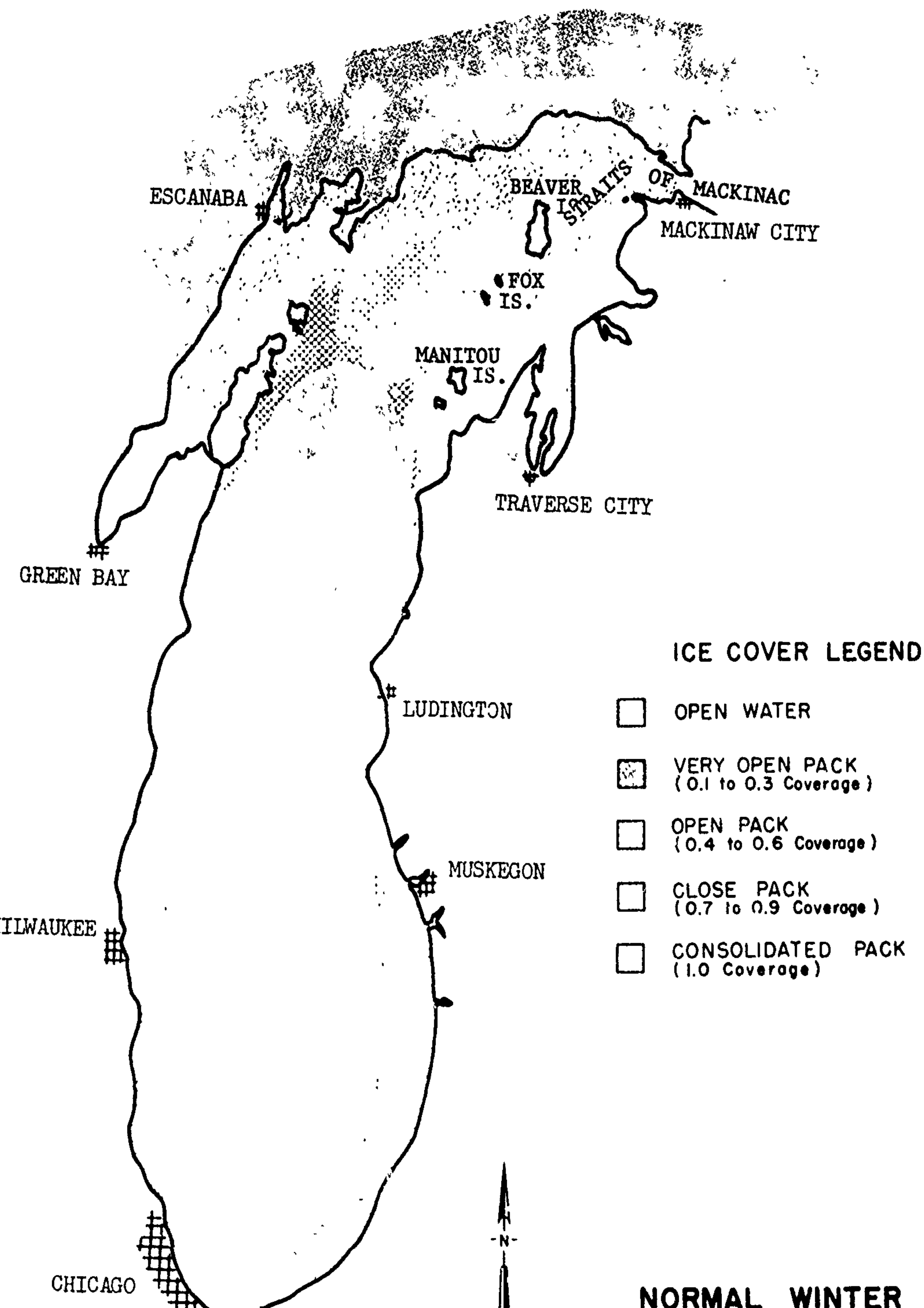
FIGURE 2

some 10 to 15 miles. From observations made during the 1976-77 winter, the lake was estimated to be 90 percent ice covered. This was the greatest areal extent of ice cover actually documented until February 1979 when coverage became 100%. Typically, during a mild winter, the lake surface can be expected to become 10 percent covered, 40 percent during a normal winter, and 80 percent during a severe winter. The maximum pattern of ice coverage of the lake for a normal winter is shown on Figure 3. During a normal winter, ice thickness can be expected to vary from 8 to 30 inches; however, some ice ridges have had recorded depths in excess of 29 feet. Because of Lake Michigan's north-south orientation, the dates of maximum freezing degree-day accumulations for the 10-year period for which records are available range from March 10 at Chicago, Illinois, in the south to March 28 at Escanaba, Michigan, at the northern end of Green Bay. The fact that ice formation and deterioration can be going on simultaneously on this lake accounts for this difference in dates.

Lake Huron

In general, the ice formation on Lake Huron begins along the eastern shoreline of Georgian Bay, along the North Channel, and the St. Marys River. Other areas of extensive ice formation during the early portion of the season are the Straits of Mackinac, Thunder Bay at Alpena, Michigan, and Saginaw Bay. From all indications, the deep north central basin of the lake rarely has an appreciable ice cover.

On 9 March 1967, the lake was observed to have ice covering approximately 80 percent of its surface, including Georgian Bay and the North Channel. In February 1979, coverage became 100%. The percent of lake surface that can be typically expected to become ice covered during the three winter classifications is: mild winter 40 percent; normal winter 60 percent; and a severe winter 80 percent.




**NORMAL WINTER**
**MAXIMUM ICE COVER**
**(March 15 - 25)**

LAKE MICHIGAN

KILOMETERS
0 25 50 75

STATUTE MILES
10 0 10 20 30 40 50 60



**FIGURE 3**

The maximum pattern of ice coverage of the lake for a normal winter is shown on Figure 4. The time interval between the dates of maximum freezing degree-day accumulations between the north and the south end of this lake is similar to Lake Michigan; the dates vary from March 11 at Port Huron to March 28 at Mackinaw City. Also, on this lake, ice formation and deterioration can be occurring simultaneously.

## Lake St. Clair

Lake St. Clair, not considered one of the five Great Lakes, is located between the southern end of Lake Huron and the northwestern end of Lake Erie and separated from those lakes by the St. Clair and Detroit Rivers. It has a surface area of 430 square miles and an average depth of only 11 feet. Because of its shallow depth and small surface area, it reacts quickly to wind conditions, changing its current patterns and consequently, the patterns of ice distribution. The initial ice formation usually occurs in the shallows of Anchor Bay, along the St. Clair Shores, Michigan area and along the eastern shore at Mitchell Bay, Ontario, on the Canadian side of the lake. As a result of the prevailing winds and currents, the western side of the lake is the last to become ice covered and the first area to be cleared of ice. The head of the Detroit River is relatively ice free for the entire winter except for minor ice jams caused by wind and current-concentrated drift ice. Small scattered open water areas appear and disappear at the mouths of the various channels of the St. Clair River delta during the entire winter. The ice, during the period of greatest cover, varies from medium to thick winter ice in the sheltered bays and shallows to thin young ice in mid-lake. Generally, the lake will attain its heaviest ice cover during the third week of January. The maximum pattern of ice coverage of the lake for a normal winter is shown on Figure 5. As the breakup of the ice cover on this lake begins, the winds and

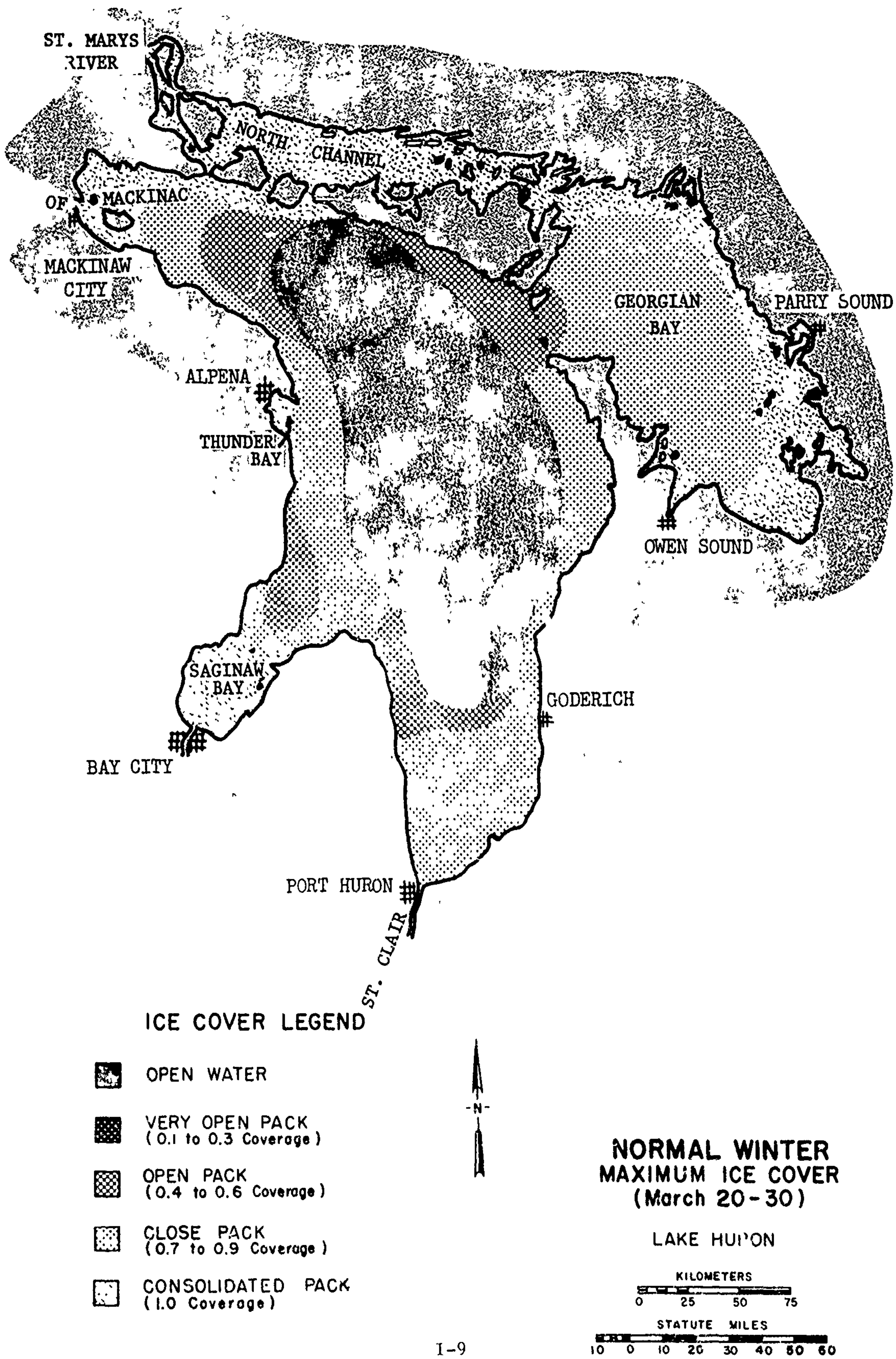
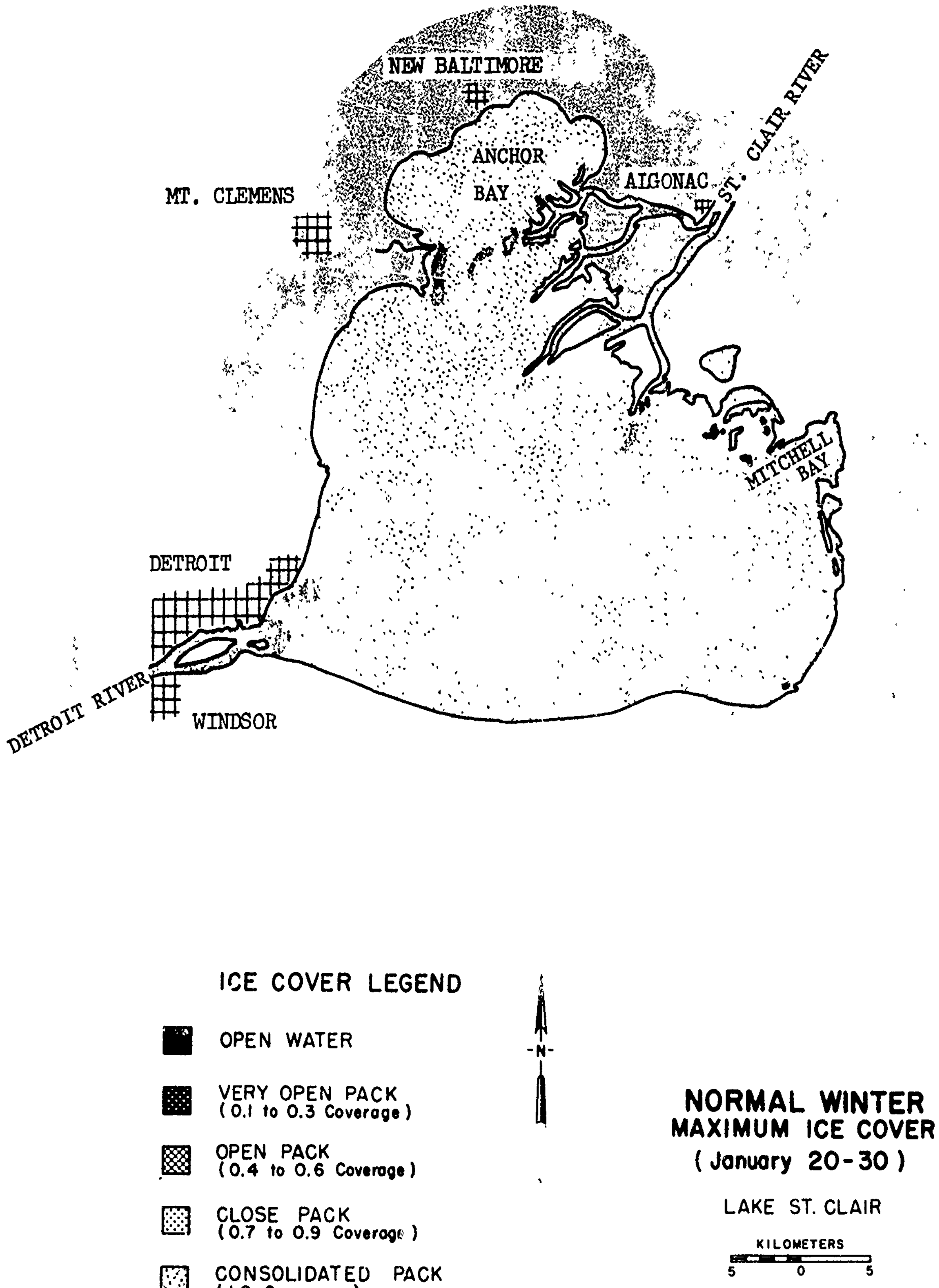

ST. MARYS
RIVER
NORTH CHANNEL
OF MACKINAC
MACKINAW CITY
GEORGIAN BAY
PARRY SOUND
ALPENA
THUNDER BAY
OWEN SOUND
SAGINAW BAY
GODERICH
BAY CITY
PORT HURON
ST. CLAIR
ICE COVER LEGEND
OPEN WATER
VERY OPEN PACK (0.1 to 0.3 Coverage)
OPEN PACK (0.4 to 0.6 Coverage)
CLOSE PACK (0.7 to 0.9 Coverage)
CONSOLIDATED PACK (1.0 Coverage)
N
NORMAL WINTER
MAXIMUM ICE COVER
(March 20-30)
LAKE HUPON
KILOMETERS
0 25 50 75
STATUTE MILES
10 0 10 20 30 40 50 60

FIGURE 4




**NORMAL WINTER**
**MAXIMUM ICE COVER**
**(January 20-30)**

LAKE ST. CLAIR

**FIGURE 5**

currents move the drifting floes to the head of the Detroit River, where strong river currents move them out of the lake and downstream. This allows the lake to become ice free in a short time. In February 1979, coverage became 100%.

Lake Erie

Lake Erie is the shallowest and most thermally unstable of the Great Lakes with an average depth of only 64 feet. This lake reacts rapidly to seasonal temperature changes and can build an appreciable ice cover in a comparatively short time (200 freezing degree-days). The areas of Lake Erie that first produce an extensive ice cover are the shallow western basin and the inner bay at Long Point, Ontario to the east. The extent of observed ice cover estimated to be in excess of 95 percent occurred on at least seven different occasions during the 1960-76 period. On each of these occurrences, the only extensive open water area observed was in the outer Long Point Bay area of the eastern basin. Coverage became 100% in February 1979 with much of this ice being very thin. Because of the lake's rapid reaction to air temperature changes and other meteorological factors, it is possible for it to attain an ice cover occupying from 95 to 100 percent of its surface area during a winter classified as normal. During a mild winter the areal extent of the ice will cover 50 percent of the lake. The maximum ice pattern for a normal winter is shown on Figure 6. The lake is rapidly cleared of ice during the thaw period except for the Buffalo area on the eastern end, where prevailing winds and currents concentrate the drifting ice. Because the capacity of the Niagara River to transport ice is so small in relation to the amount of ice usually present, almost all of the ice must melt in the lake. Since 1964, an ice boom has been placed annually at the head of the river to reduce the duration and frequency of damaging ice runs. The boom is removed during the latter part of the ice season. There is no evidence that use of the

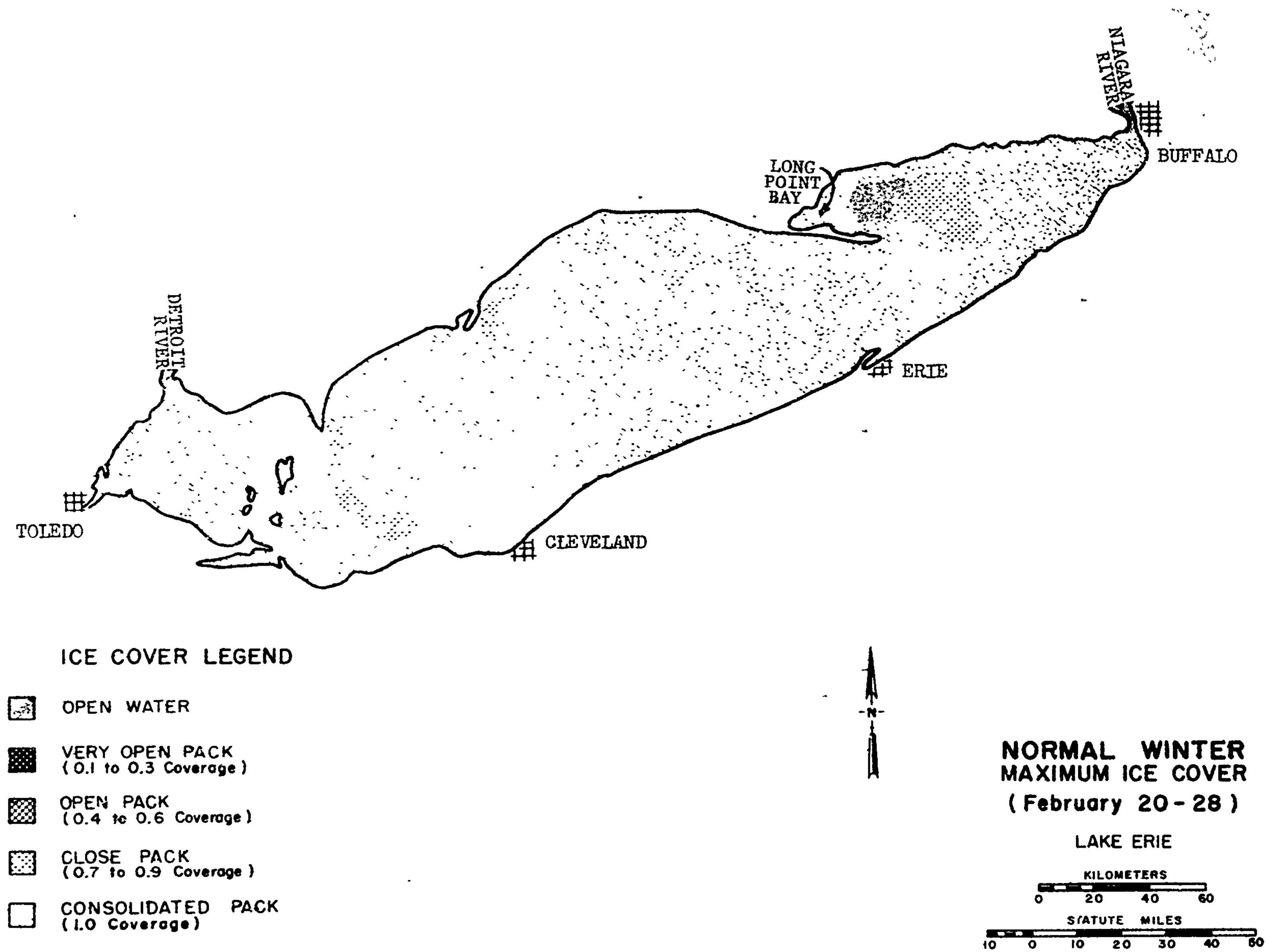

NORMAL WINTER
MAXIMUM ICE COVER
( February 20 - 28 )
LAKE ERIE
KILOMETERS
0 20 40 60
STATUTE MILES
10 0 10 20 30 40 60
N
NIAGARA RIVER
BUFFALO
LONG POINT BAY
ERIE
CLEVELAND
DETROIT RIVER
TOLEDO
ICE COVER LEGEND
OPEN WATER
VERY OPEN PACK (0.1 to 0.3 Coverage)
OPEN PACK (0.4 to 0.6 Coverage)
CLOSE PACK (0.7 to 0.9 Coverage)
CONSOLIDATED PACK (1.0 Coverage)

FIGURE 6

boom has measurably prolonged the duration of the natural ice season in eastern Lake Erie. The average dates of maximum accumulation of freezing degree-days for Lake Erie vary from March 5 in the west to March 15 in the northeastern end of the lake.

Lake Ontario

Lake Ontario, with its mean depth of 283 feet second only to Lake Superior, has the smallest surface area of all the Great Lakes. The small surface area and great depth give Lake Ontario a large heat storage capacity, causing it to respond slowly to changing air temperatures, and thereby producing a small ice cover. The ice cover on Lake Ontario generally forms first in the Bay of Quinte, Ontario, and the shallow areas at the approaches to the St. Lawrence River. On this lake, as on Lake Erie, the prevailing winds and currents tend to confine and concentrate the ice cover at the northeastern end. The extent of ice cover that can be expected to form during the winter season classifications is: 8 percent of the surface area during a mild winter, 15 percent for a normal winter, and 25 percent for a severe winter. The maximum pattern of ice cover for a normal winter is shown on Figure 7. From the examination of available ice formation and temperature data, an ice cover of more than 25 percent of the surface area of Lake Ontario would indeed require a severe winter. In February 1979, the coverage became 90-95%, the majority of the ice being very thin.

Outlet Rivers

<u>St. Marys River</u>

The St. Marys River is the completely regulated outlet of Lake Superior. It extends from Whitefish Bay approximately 70 miles downstream to Lake Huron and falls about 22 feet. Most of the fall

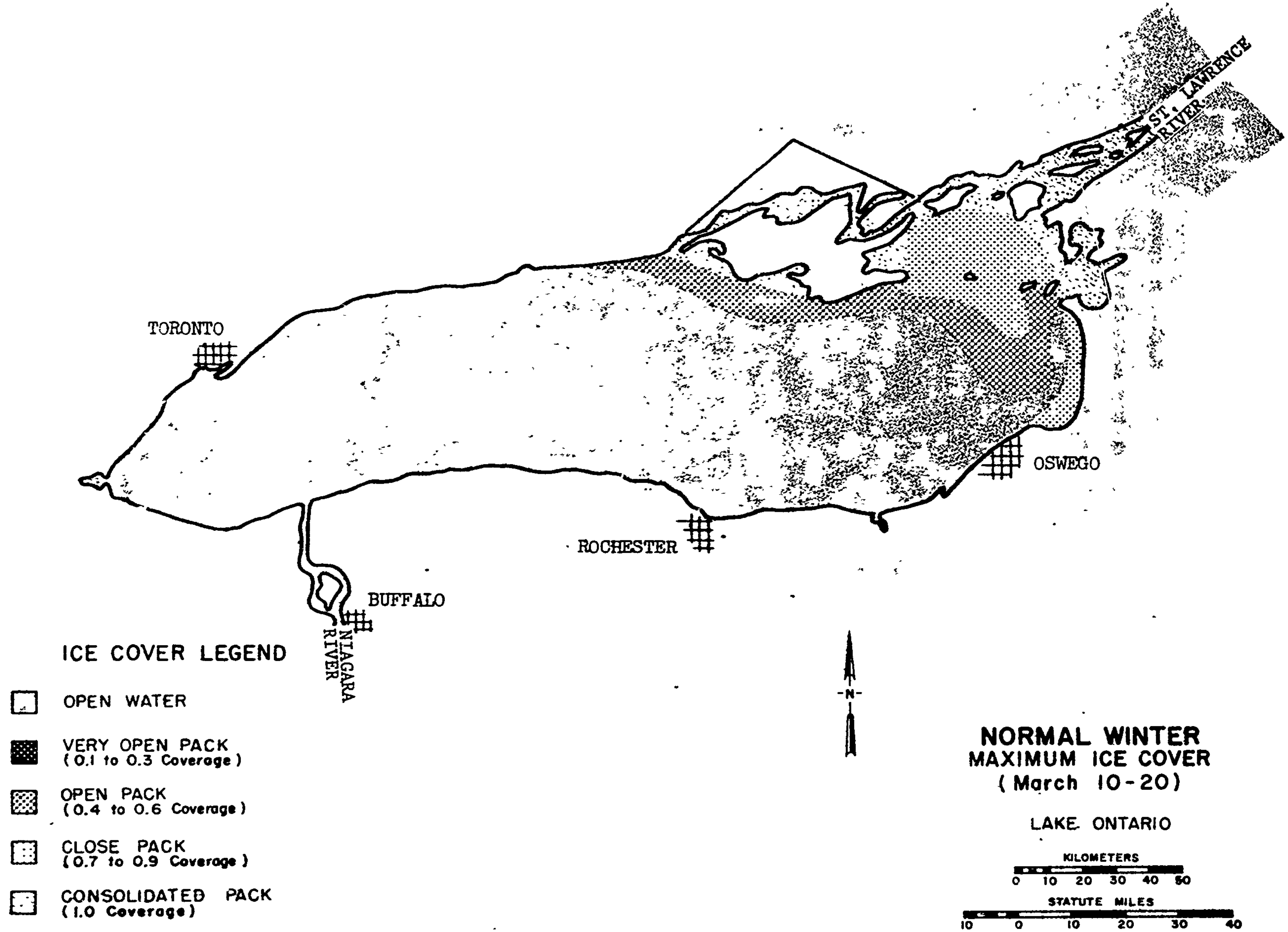

NORMAL WINTER
MAXIMUM ICE COVER
( March 10-20)
LAKE ONTARIO
KILOMETERS
0 10 20 30 40 50
STATUTE MILES
10 0 10 20 30 40
-N-
ST. LAWRENCE RIVER
TORONTO
OSWEGO
ROCHESTER
BUFFALO
NIAGARA RIVER
ICE COVER LEGEND
OPEN WATER
VERY OPEN PACK
(0.1 to 0.3 Coverage)
OPEN PACK
(0.4 to 0.6 Coverage)
CLOSE PACK
(0.7 to 0.9 Coverage)
CONSOLIDATED PACK
(1.0 Coverage)

FIGURE 7

occurs in the mile-long St. Marys Rapids located between the cities of Sault Ste. Marie, Michigan, and Ontario. The flow in the river has been completely controlled since 1921 by means of a gated control dam above the rapids. In addition to the control dam, there is one Canadian power dam, one Canadian lock, 4 U.S. locks, and 2 U.S. power dams. Figure 8 shows the above area and a typical winter distribution of flow through the structures.

The International Lake Superior Board of Control, which was established pursuant to Orders of Approval issued by the International Joint Commission in May 1914, determines monthly the amount of the release of water. This Board directly supervises the operation of the river control works and diversion of flows to the power plants. It is charged with maintenance of Lake Superior levels as near as may be between the elevations of 600.5 and 602.0 feet IGLD (1955). In addition, the outflow is controlled to prevent the river levels in Soo Harbor, below the locks, from rising above the flood elevation of 582.9 feet.

The discharge of the St. Marys River has averaged 75,000 cubic feet per second (cfs) during the period 1900-1978. The maximum recorded monthly outflow was 127,000 cfs in August 1943. The minimum was 41,000 cfs in September 1955 which occurred during a strike at the Edison Sault Power Plant. During the winter months, December through April, under the current regulation scheme, outflows are kept within a limited range of 55,000 to 85,000 cfs. The minimum outflow allows a minimum supply of water to the hydroelectric plants and locks, with a mandatory 1/2 gate open on the control dam to provide environmental protection for the rapids area. The maximum winter outflow is established at 85,000 cfs. Flows in excess of this amount have resulted in breakup of the downstream ice cover, ice jams and flooding problems in Soo Harbor. Gates on the control structure are generally kept at one setting during the winter months because heavy ice accumulation on the gates makes any change difficult. Winter


DISTRIBUTION OF MONTHLY FLOW AT ST. MARYS RAPIDS (JAN. 1977)

FIGURE 8

gate movement is possible, but involves extensive chipping and steaming to remove ice from the individual gates and controls.

Downstream of Soo Harbor, the river divides into two channels around Sugar Island. About 70 percent of the flow passes through the 600 foot wide navigation channel called Little Rapids Cut. Immediately downstream of the cut, the river widens into a broad, shallow reach called Lake Nicolet, which generally maintains a solid ice cover throughout the winter. The head of the cut generally remains open much of the winter. Historically, loose ice from Soo Harbor, broken by wind, tends to drift into the cut. At times, this loose ice accumulates in layers in the cut, which: (1) builds upstream until it hampers Sugar Island ferry operations; (2) hampers winter navigation; and (3) causes water levels to rise upstream in Soo Harbor.

In an effort to stabilize the ice in Soo Harbor and reduce the downstream flow of ice in Little Rapids Cut during the Winter Navigation Demonstration Program, the U.S. Army Engineer District, Detroit, designed and installed an ice boom across the entrance to the cut just upstream of the Sugar Island ferry crossing (see Figure 9). The boom was first installed prior to the ice season in November 1975 and has been re-installed each November to date. The boom is installed in two sections, extending about 450 feet on the mainland side and 1,200 feet out from Sugar Island, leaving a 250 foot opening for ships to pass through. The booms are effective in maintaining an ice cover similar to that experienced in winters prior to winter navigation. Analysis of water level gauge records during the past three winters indicates the booms do not have a measurable effect on levels of Soo Harbor or on the river profile. In other words, the booms have allowed navigation to proceed without affecting levels and flows to a measureable degree. (For a detailed analysis of the effects of the ice boom, see the Annual Report entitled, "Report on the St. Marys River Ice Boom and its effects on Levels and Flows in the Soo Harbor Area," by the Detroit District, Corps of Engineers.)

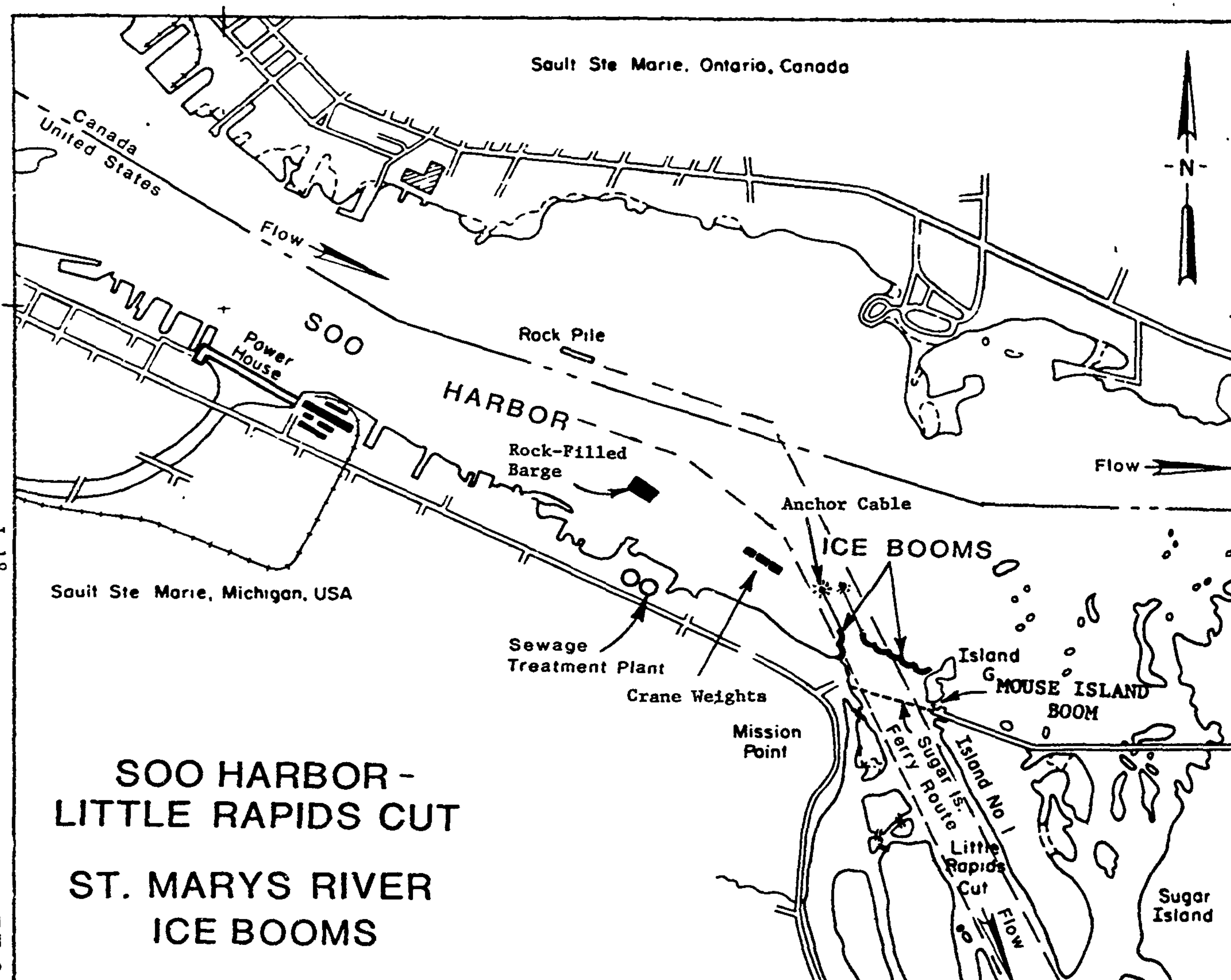

Sault Ste Marie, Ontario, Canada
N
Canada
United States
Flow
SOO
HARBOR
Power House
Rock Pile
Rock-Filled Barge
Flow
Anchor Cable
ICE BOOMS
Island G
MOUSE ISLAND BOOM
Island No I
Sugar Is. Ferry Route
Little Rapids Cut
Flow
Sugar Island
Mission Point
Crane Weights
Sewage Treatment Plant
Sault Ste Marie, Michigan, USA
SOO HARBOR - LITTLE RAPIDS CUT
ST. MARYS RIVER ICE BOOMS

FIGURE 9

Another factor that impacts on Soo Harbor levels is the backwater effect from Lake Huron. The difference in water levels between Soo Harbor and Lake Huron generally varies between one and two feet, depending upon outflow and Lake Huron elevation. Easterly and southerly winds can raise the water surface at the northern end of Lake Huron and, consequently, raise the level of Soo Harbor.

A portion of the flow proceeds around the northern side of Sugar Island, through what is known as the Lake George Channel. The channel carries about 30 percent of the total flow during open water periods. It is relatively shallow and is now used only for small boat traffic. During the last century, it was used by commercial vessels until the Little Rapids Cut was dredged through a series of rapids to become the current navigation channel. The International Boundary bisects the Lake George Channel around Sugar Island. The flow in the Lake George Channel continues past Sugar Island around St. Joseph Island before rejoining the mainstream north of Detour Passage. (See Figure 10)

Downstream of Lake Nicolet, the Little Rapids flow divides around Neebish Island into the West and Middle Neebish Channels. The West Neebish Channel carries about 28 percent of the total river flow. It passes through a rectangular rock walled channel 300 feet wide, 27 feet deep, and 1-3/4 mile long known as Rock Cut. The Channel was excavated around the turn of the century through a series of rapids that separated Neebish Island from the U.S. mainland. The West Neebish Channel is used primarily by downbound vessels during the summer months. In winter it is traditionally closed to all navigation and a stable ice cover develops upstream and downstream of the Rock Cut.

During the winter months, December through March, all ship traffic is confined to the Middle Neebish Channel. The downbound

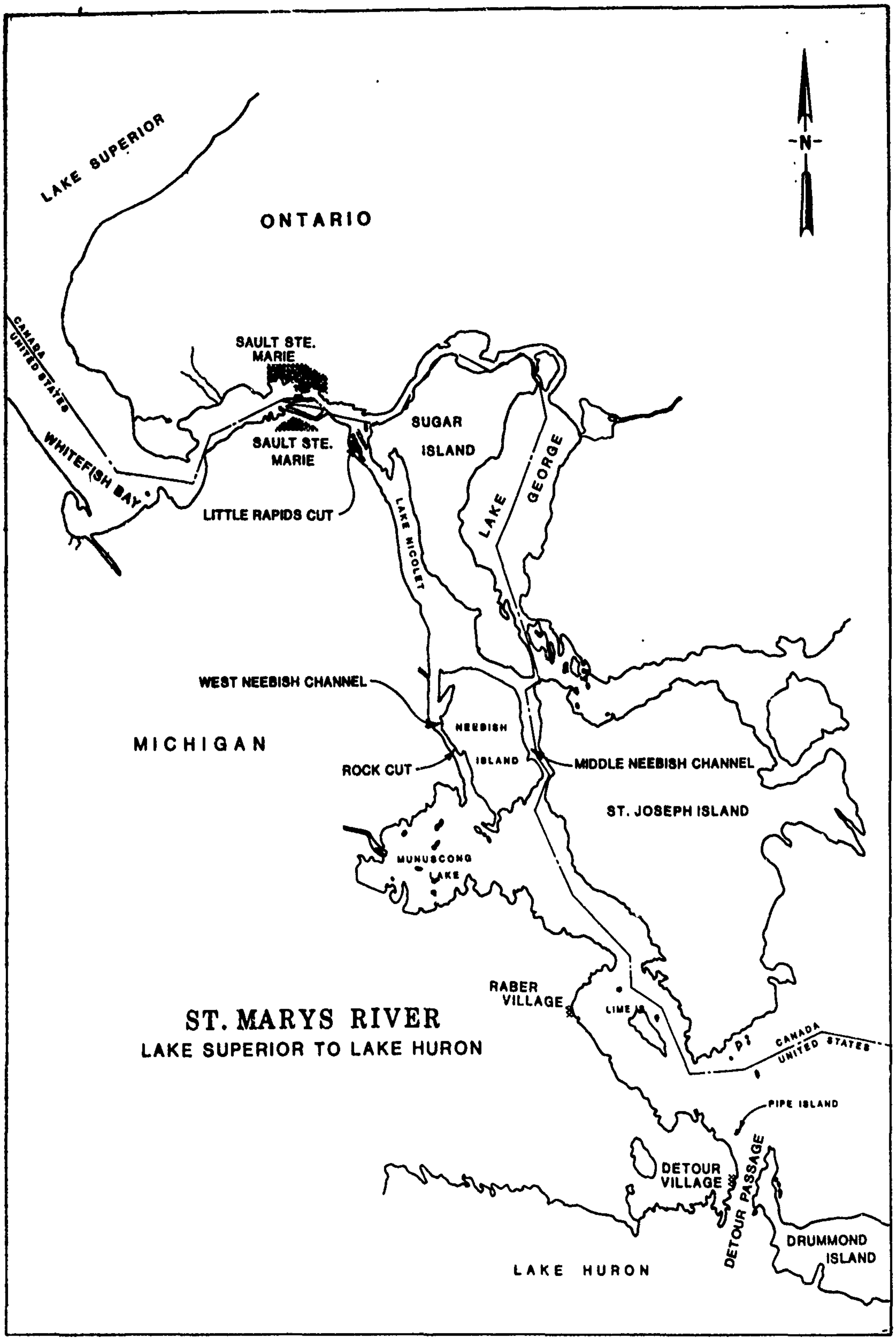

LAKE SUPERIOR
ONTARIO
CANADA
UNITED STATES
WHITEFISH BAY
SAULT STE. MARIE
SAULT STE. MARIE
SUGAR ISLAND
LITTLE RAPIDS CUT
LAKE NICOLET
LAKE GEORGE
N
WEST NEEBISH CHANNEL
MICHIGAN
NEEBISH ISLAND
ROCK CUT
MIDDLE NEEBISH CHANNEL
ST. JOSEPH ISLAND
MUNUSCONG LAKE
RABER VILLAGE
LIME IS.
CANADA
UNITED STATES
ST. MARYS RIVER
LAKE SUPERIOR TO LAKE HURON
PIPE ISLAND
DETOUR VILLAGE
DETOUR PASSAGE
DRUMMOND ISLAND
LAKE HURON

FIGURE 10

traffic is loaded while the upbound traffic is empty. This longer channel around the east side of Neebish Island has numerous turns and narrow reaches which traditionally develop a heavy ice cover. Continued ship traffic causes the ice to layer and build up in the turns, making navigation difficult. Traffic control has been necessary to allow only one-way traffic at any given time.

Downstream of Neebish Island, the river broadens into the wide shallow expanse of Lake Munuscong where current velocities are extremely low. The 22 mile reach between Neebish Island and DeTour Passage is essentially at Lake Huron elevation. It is usually the first area to freeze over in early winter and the last to break up in the spring. Ice thickness often exceeds 3 feet in the undisturbed areas and becomes considerably thicker adjacent to and in the navigation track and turns where vessel movement causes a build-up by pushing floes under the existing cover.

The mile wide DeTour Passage, between Drummond Island and the Upper Peninsula mainland, is the navigation outlet of the St. Marys River into Lake Huron at Point DeTour. An automobile ferry operates across the passage between Drummond Island and DeTour, Michigan. This area generally remains open much of the winter. A natural ice bridge forms across the northern edge of the passage between the mainland, Pipe Island, and Drummond Island. The ice arch may extend south to the ferry crossing during extended periods of cold weather. Current velocities are very low in the passage. Ice floes from Lake Huron and loose ice from north of the passage tend to move both north and south through the passage under the influence of prevailing winds.

Occasionally, the passage becomes filled with ice which remains until strong northerly winds move the ice south into Lake Huron. During these periods the ferry has difficulty in maintaining an open

track across the river. At other times, loose ice is blown against the ferry landings which greatly hampers its docking.

## Straits of Mackinac

Lakes Michigan and Huron share a common water surface elevation and are considered hydraulically as one lake. Current direction and velocities through the Straits vary with the predominant wind direction, but the net flow is from Lake Michigan to Lake Huron. This outflow has been estimated to average about 52,000 cfs. Because of the relatively wide expanse of the Straits, the average current velocity is less than 0.1 foot per second. A significant ice cover generally forms in this area, extending east and west into both lakes, causing difficulty for transiting ships also aggravated by shifting ice.

## The St. Clair-Detroit Rivers

The St. Clair-Detroit River system extends from the southern end of Lake Huron approximately 86 miles into Lake Erie. The system is divided into three distinct parts: the St. Clair River, which has a length of 39 miles; Lake St. Clair, with a vessel travel distance of 16 miles between the mouth of the St. Clair River and the head of the Detroit River; and the Detroit River which extends 32 miles to Lake Erie.

## St. Clair River

The monthly discharge of the St. Clair River averages about 180,000 cubic feet per second (cfs) but has varied between 106,000 cfs and 232,000 cfs during the period 1900 to 1978. The rate of discharge is predominantly determined by the upstream and downstream lake elevations; but the discharge is also affected by changes in the channel area and by the retardation effect of ice.

The St. Clair River has a fall of about 5 feet. The upper portion of the river is a relatively straight channel from its head at Port Huron, Michigan, downstream 29 miles to Algonac, Michigan. There it branches into three major channels (North, Middle, and South Channels) and numerous smaller channels in a delta area known as the St. Clair Flats, before entering Lake St. Clair. The narrowest portion of the river, which is 800 feet wide for a distance of about 1,300 feet, occurs at the outlet of Lake Huron in the vicinity of the Blue Water Bridge. At this location, current velocities are at a maximum, averaging 5 to 6 feet per second (fps), but often exceeding 10-12 fps under the influence of northerly winds on Lake Huron. Downstream of this narrow restriction at Port Huron, the river becomes 1/4 to 1/2 mile wide. Current velocities are swift, averaging 2.5 to 5 feet per second, which prevent a stable ice cover from forming.

Downstream of Algonac, Michigan, the main navigation channel is through the South Channel. During the period 1959 to 1962, the lower end of the South Channel was straightened with a dredged cut-off canal into Lake St. Clair, eliminating passage through the old Southeast Bend Channel.

Historically, during the winter, floe ice from Lake Huron enters the river, generally under the influence of northerly winds. The current carries the floes downstream until meeting the resistance of the solid ice cover of Lake St. Clair. The broken ice pieces tend to compress into a jagged ice cover that backs upstream as more ice enters the system. During a normal winter, the ice cover may extend upstream 5 to 10 miles. There have been extreme periods when it extended nearly to Lake Huron. The main factor which influences the amount of ice entering the river is the stability of an ice bridge

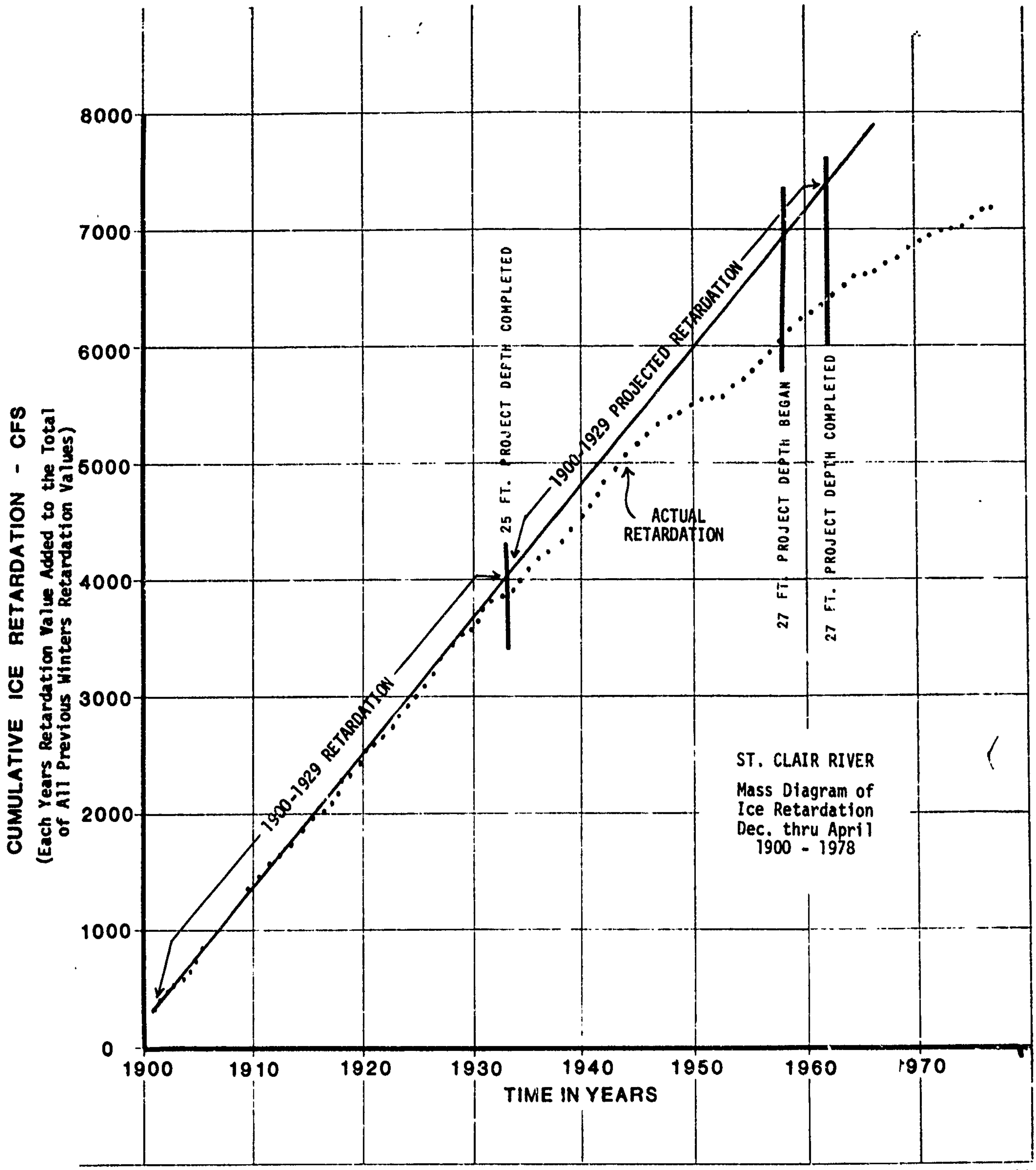
(natural ice arch) that forms in lower Lake Huron at the head of the river. This occurs when a large sheet of ice becomes lodged in the narrowing confine to the river opening and prevents additional ice from entering the system. It also causes lake ice pieces to consolidate and freeze together into a solid, stable sheet bridging the river entrance from the U.S. to Canada. This condition may last through the winter or may be disrupted by southerly winds which tend to break up the ice cover. When the wind shifts back to northerly, the broken ice is pushed into the river. As the broken ice reaches the ice cover of the lower river, pieces are pushed against it. Those that lodge vertically extend below the bottom of the ice cover and trap pieces shoved under the ice pack. In extreme cases, this process continues until an ice jam occurs which may reduce the river flow by half. Ice not trapped, passes under the ice cover, through the channels in the lower St. Clair River and into Lake St. Clair.

The presence of the downstream ice cover causes a paradox of both beneficial and adverse effects. Beneficially, the retardation effect of the ice cover produces a natural regulation of the outflows. Water that would normally flow through the river under open water conditions is stored on the upper lake. The reduced outflow also reduces supply to Lakes St. Clair and Erie, causing their levels to drop throughout most of the winter. Conversely, the ice buildup in the lower river has hampered the limited winter navigation which has occurred traditionally and during the Demonstration Program. The ice cover tends to layer and compact under the influence of wind and current. Icebreaker assistance is required at times to escort ships through the most critical reach between Algonac, Michigan, and Lake St. Clair. (Reference: Great Lakes Basin Framework Study, Appendix II, Levels and Flows, by the Great Lakes Basin Commission, 1975.)

Over the years, some portions of the St. Clair River have been deepened and straightened, which has resulted in a lessening of ice buildup and ice retardation in the river. These improvements for navigation allow ice to exit the system at a faster rate, thereby decreasing the natural retardation effect discussed earlier. An analysis of computed ice retardation for the period 1900-1978 indicated that a lower degree of ice retardation began to be experienced in the mid 1930's (see Figure 11) following completion of the construction of the 25 foot deep draft channel. Figure 11 also shows that the construction of the new St. Clair cut-off channel (1960-62), and deepening of the channel to 27 feet also decreased the degree of ice retardation being experienced. This evidence would indicate that these changes not only resulted in more efficient channels for navigation but for ice passage as well. The flow retardation caused by ice in the St. Clair River during the period 1930 through 1978 averaged about 3,000 cfs in December, 26,000 cfs in January, 32,000 cfs in February, 12,000 cfs in March, and about 1,000 cfs in April. This is in comparison with the average for the period 1900 through 1929 of about 4,000 cfs in December, 36,000 cfs in January, 48,000 cfs in February, 23,000 cfs in March, and 6,000 cfs in April.

## Lake St. Clair

Lake St. Clair is a shallow oval shaped basin with an average depth of 11 feet and a maximum depth of 21 feet, except for the manmade navigation channel which has been dredged to a depth of 27 feet. The lake is about 26 miles long by 24 miles wide and is considered part of the connecting channel between Lakes Michigan-Huron and Erie. Because the lake is relatively small and shallow, it generally retains a stable ice cover throughout the winter.



CUMULATIVE ICE RETARDATION - CFS
(Each Years Retardation Value Added to the Total of All Previous Winters Retardation Values)
8000
7000
6000
5000
4000
3000
2000
1000
0
1900
1910
1920
1930
1940
1950
1960
1970
TIME IN YEARS
1900-1929 RETARDATION
1900-1929 PROJECTED RETARDATION
ACTUAL RETARDATION
25 FT. PROJECT DEPTH COMPLETED
27 FT. PROJECT DEPTH BEGAN
27 FT. PROJECT DEPTH COMPLETED
ST. CLAIR RIVER
Mass Diagram of
Ice Retardation
Dec. thru April
1900 - 1978




FIGURE 11

## Detroit River

The Detroit River flows in a southwesterly direction, a distance of 32 miles, from Lake St. Clair to Lake Erie. It falls about 3 feet between the two lakes and has an average discharge of 185,000 cfs.

The upper portion of the river has a deep, unobstructed channel except for Peach Island and Belle Isle at its head. The lower portion of the river is broad and shallow. It is characterized by many islands, channels and compensating dikes. The navigation channels are cut through an extensive limestone outcrop. During open water conditions, downbound traffic travels through the 600-foot wide rock-diked Livingstone Channel, west of Bois Blanc Island, Ontario. Upbound traffic travels the wider, less straight, Amherstburg Channel east of Bois Blanc Island. During the winter months, all ship traffic uses the Livingstone Channel as the most direct and ice-free route. Compensating dikes were constructed in the Detroit River to control the discharge capacity by an amount equal to most of the navigation improvements brought about by the 25 foot and 27 foot navigation projects. In other words, the dikes were built to maintain water levels at normal elevations in spite of the enlarged channels allowing increased flow to occur.

Ice conditions are considerably different in the Detroit River from those in the St. Clair River. A large ice bridge or arch develops at the head of the Detroit River upstream of Peach Island in Lake St. Clair. Downstream, the river remains open due to the swift current. A downstream ice cover develops in the broad shallow areas among the lower islands, but generally, the main navigation channels, particularly the Livingstone Channel, remain open if ice entering the channel can flow through into Lake Erie. Ice in western Lake Erie tends to shift around in large sheets under the influence of prevailing winds. Westerly winds will generally create large areas of open water downstream of the Livingstone Channel and absorb any

ice floating through the system. Easterly winds blow ice into the lower river and cause jams that both raise upstream levels and hamper navigation.

Floe ice enters the upper Detroit River from the deterioration of the Lake St. Clair ice bridge. The bridge remains stable in the open lake one to two miles above Peach Island. During periods of subfreezing temperatures, the edge of the ice bridge extends downstream to Peach Island, forming an ice arch on either side of the island. During periods of above freezing temperatures, the ice bridge erodes back into the lake under the influence of wind and river current, causing large sheets of ice to drift downstream. If Lake Erie ice blocks the lower end of the river, ice back-up results. Occasionally, during a prolonged warm spell or an early spring breakup on Lake St. Clair, the entire river may fill with ice. Downstream flooding does not appear to be a serious problem because most of the shoreline development is designed to tolerate occasional high levels resulting from the seiche effect on Lake Erie. Strong easterly winds temporarily raise western Lake Erie levels which, at times, exceed 7 feet above chart datum. This effect is carried up the Detroit River such that, on rare occasions, the flow has actually reversed direction for a short period. Winter flows are computed utilizing ice-free reaches, wherever they exist, because the retardation effects of an ice cover or ice jams cause abnormal levels in those areas. These computations indicate that the average flow retardation caused by ice in the Detroit River for the period 1930 through 1978 is about 5,000 cfs in December, 10,000 cfs in January, 6,000 cfs in February, 2,000 cfs in March, and 1,000 cfs in April. This is in comparison with the average for the period 1900 through 1929 of about 5,000 cfs in December, 15,000 cfs in January and February, 8,000 cfs in March, and 2,000 cfs in April.

## Niagara River

The Niagara River forms the natural outlet from Lake Erie. It flows in a northwesterly direction about 36 miles into Lake Ontario as shown on Figure 1. Total fall between the two lakes is about 327 feet. The river drops about 10 feet in the first 24 miles, another 55 feet in the mile-long rapids above Niagara Falls, about 185 feet over the falls and another 77 feet through a series of cascades and rapids to Lake Ontario. The average discharge of the river between 1900 and 1978 was about 198,000 cfs. It has varied betwee a minimum flow of 116,000 cfs to a maximum of 265,000 cfs.

A small amount of water (yearly average 700 cfs) is diverted out of the Niagara River upstream of the falls at Tonawanda, New York, to flow through the New York State Barge Canal. This diversion has occurred since 1825. High water levels of the canal are discharged into Lake Ontario at several places along the route. The final point of outflow for waters diverted from the Niagara River is through the Oswego Canal, a 30 mile long canal discharging into Lake Ontario at Oswego, New York.

Following the construction of the two hydroelectric power plants, in 1962, by Ontario Hydro on the Canadian side and the Power Authority of the State of New York (PASNY) on the U.S. side, the flow over Niagara Falls has been partially regulated by an 18-gate structure extending about halfway across the river. By international treaty, a minimum of 100,000 cfs must flow over the Falls during the daylight hours of the tourist season, May through October. At other times, a minimum of 50,000 cfs must flow over the falls. The remainder of the river flow can be diverted for power purposes. This control structure, being about 20 miles downstream, has no detectable effect on the Lake Erie outflows.

Without the gated structure, these large power diversions would have lowered levels of the Niagara River about 4 feet in the vicinity of the intakes and would have significantly lowered the levels of the upper river. To compensate for the power diversion, a structure was constructed downstream of the intakes. The structure is 2,120 feet long and has 18 gates, each 100 feet long and 10.5 feet high. The structure is operated to maintain the river level, with certain allowable tolerances, at the long term average level that prevailed at the site of the control structure before its construction.

Historically, ice has been a problem in the Niagara River. The Lake Erie ice field near the entrance to the river usually arches between the Canadian and United States shore and restricts movement of lake ice into the river. When the ice is forming, or when the lake is under adverse conditions of wind and temperature, the arch and the ice behind it may break and cause ice to jam in the river above the falls. The jams would greatly restrict the flow necessary for power production and also cause extensive shoreline damage in the Upper Niagara River.

Each winter, since 1964, the two power entities (Ontario Hydro and PASNY) have installed an ice boom at the outlet of Lake Erie. The boom appears to be effective and has significantly reduced shore property damage and losses to power production. (The operation of this boom is detailed in each annual report by the International Niagara Board of Control to the International Joint Commission entitled, "Operation of Lake Erie-Niagara River Ice Boom.")

Since vessels use the Welland Canal between Lake Erie and Lake Ontario to bypass Niagara Falls, there would be no effect on the flows of the Niagara River as a result of winter navigation.

## Welland Canal

In addition to Lake Erie outflow through the Niagara River, some water is diverted through the Welland Canal, located in Canada, about 10 miles west of the head of the river. This is the main navigation canal between Lakes Erie and Ontario. It contains 8 locks and allows ships to overcome the 327 foot difference between Lakes Erie and Ontario. Since 1950, the Welland diversion has averaged between 7,000 and 8,000 cfs. This water is principally used to operate the locks (700 cfs) and to generate power at the DeCew Falls hydroelectric plant (6,400 cfs).

At the present time, during the early winter months, limited navigation through the canal occurs when mild ice and weather conditions permit the locks to operate. Under a condition of full navigation season extension, greater use of the Canal would be essential. The average April-November flow through the Canal for the period 1965-1978 was approximately 8,100 cfs. The average for the traditional non-navigation season (December-March) flow over the same period (excluding winter 1972-1973 when the Canal was shut down for modifications) was 7,300 cfs.

## St. Lawrence River

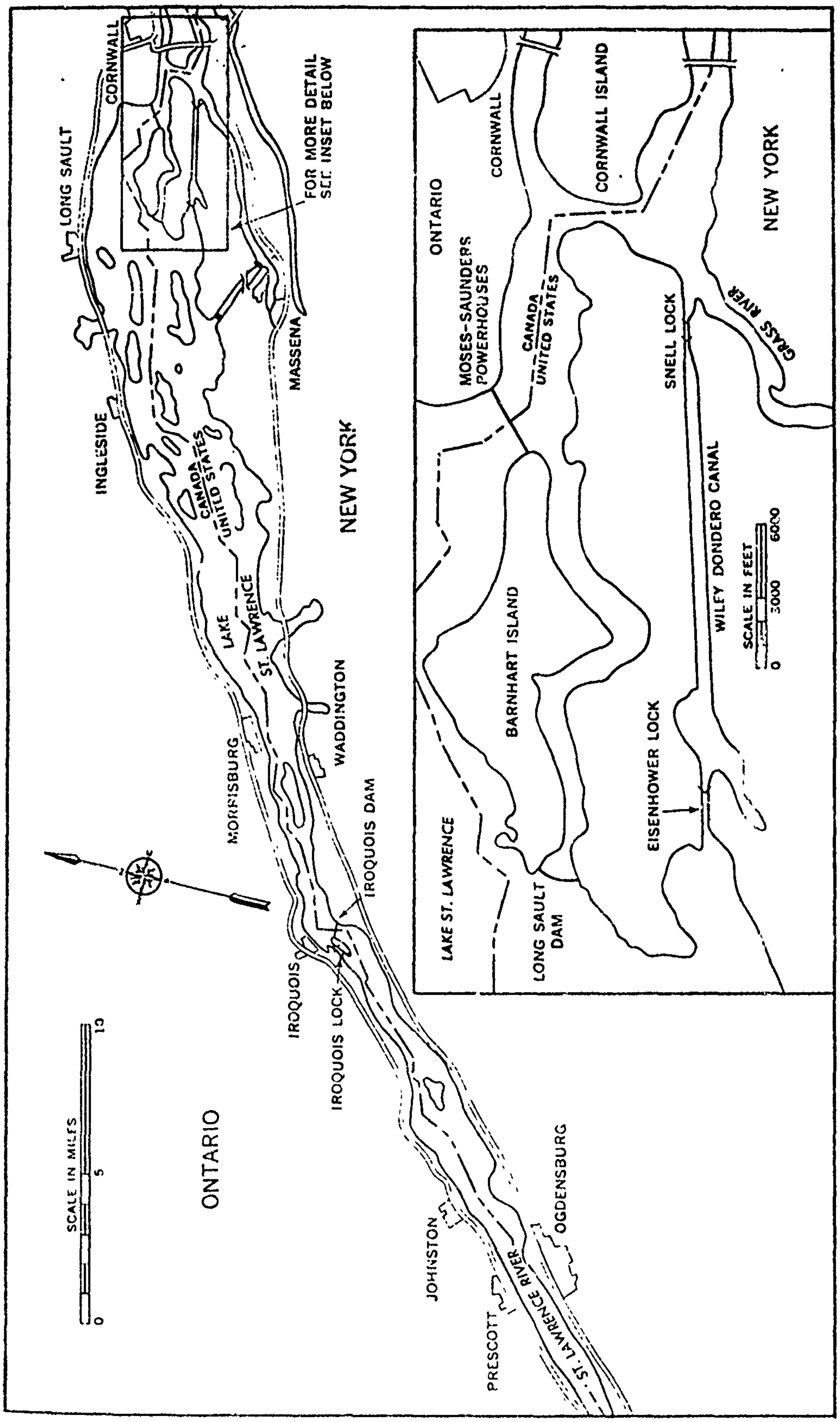
The St. Lawrence River is the natural outlet from Lake Ontario to the Gulf of St. Lawrence. It flows in a northeasterly direction a distance of 530 miles, falling about 246 feet through a series of power dams and locks. The average discharge of the river between 1900 and 1978 was about 238,000 cfs. Most of the fall, about 226 feet, occurs between Lake Ontario and Montreal Harbor, a distance of about 183 miles. Most of the remaining 20 feet of fall occurs in the 160 miles between Montreal and Quebec City. The river can be divided into two reaches when discussing navigation. Below Montreal,

navigation operates at most times throughout the winter with the assistance of icebreakers. However, above that point, navigation has traditionally ended in the mid to latter part of December.

Regulation of Lake Ontario began in April 1960 as part of the St. Lawrence Seaway and Power Project. Principal regulatory works are shown on Figure 12. These structures control the total outflow from Lake Ontario. The Moses-Saunders Power Dam extends 3,300 feet across the St. Lawrence River from Barnhart Island, New York, to Cornwall, Ontario. The total river discharge, except for that which is needed for navigation and domestic use, normally flows through this dam. The channel south of Barnhart Island is closed by the 3,000 foot Long Sault Flood Control Dam. It contains thirty spillway gates and can handle the entire river discharge, if required. The power pool, known as Lake St. Lawrence, extends 25 miles upstream from the Moses-Saunders power dam to Iroquois Dam. Iroquois Dam is a 1,800 foot long structure which can be used in an emergency to control the entire outflow from Lake Ontario. However, since 1960, Iroquois Dam has operated only a few days each year for ice formation and/or ice control, or for reducing seiche effects.

The portion of the St. Lawrence River which extends upstream from the Moses-Saunder Power Dam to Lake Ontario is known as the International (Canada and U.S.) Section of the river. The portion downstream of the power dam to the Gulf of St. Lawrence is known as the National (Canada only) Section.

Lake Ontario's outflow is regulated to satisfy the International Joint Commission's Orders of Approval dated October 29, 1952, and July 2, 1956. The "Order" contains a series of criteria for the regulation of Lake Ontario so that the benefits of regulation are equitably distributed among the navigation, power, and riparian interests. The plan (1958-D) which is currently in use was designed and tested using the water supply sequence experienced from 1860




LAKE ONTARIO REGULATORY WORKS

FIGURE 12

through 1954. The International St. Lawrence River Board of Control is charged by the International Joint Commission with the responsibility for the regulation of the lake and satisfaction of the criteria.

The regulation plan currently in use does not provide for navigation beyond about mid-December nor before about 1 April of each year. During this period a series of ice booms are installed in the Canadian Beauharnois Power and Navigation Canal upstream of Montreal and in the International Rapids Section of the River. It is desirable that these ice booms be installed prior to the onset of ice conditions so that the formation of an ice cover can be accelerated, ice movement minimized, the risk of jamming decreased, and, as a consequence, the discharge capacity of the river maintained for the remainder of the winter. In addition, as part of the St. Lawrence River Power and Navigation project, dredging was done in the river to improve navigation depths and provide velocities suitable for ice formation. Of particular concern now and during any planned winter navigation operations, is the Cardinal to Ogden Island reach where slush ice and floes feed the upstream end of the stable ice cover forming a hanging ice dam (reported thicknesses to 30 feet). The regulation plan also provides for a reduction in flow during the early winter period to aid in the formation of this stable ice cover. The maintenance of this stable ice cover is critical on this river to prevent the formation of additional ice in quantities that would result in jamming, which could stop ship movement, cause flooding upstream of the jam, and reduce the water available for power production. Any disturbance of the ice cover by meteorological conditions, or from other effects may cause reduced discharges from Lake Ontario, consequently raising Lake Ontario levels and, under high water supply conditions, could result in shoreline damage on Lake Ontario.

Currently, there is no attempt in the plan of regulation to maintain low water datum (minimum depths for navigation) elevation in the St. Lawrence River during the winter months. Hence, during this period, weekly average depths can be as much as 4 feet below that required for the minimum navigation depths. Ice thickness in the channel sections may average 2 to 3 feet with maximum thicknesses in areas where ice piles up 20 to 30 feet, while lake ice may only reach a thickness of 1.5 to 2.5 feet. (The Annual Report on Ice Phenomenon - St. Lawrence Power Project, produced by the Power Authority of the State of New York and Ontario Hydro for the Operations Advisory Group of the International St. Lawrence River Board of Control. Each of the annual reports contains information pertinent to the formation, retention, and deterioration of the ice cover in the International Section of the St. Lawrence River.)

## DESCRIPTION OF THE PROBLEM

The levels of the Great Lakes reflect the total supply of water to the lakes and that which flows out through their connecting channels. Since these channels are presently subject to blockage or retardation due to ice, anything which affects this natural process could, in turn, impact on the lake levels. Since, historically, significant navigation ends by mid-December, extension of the season could have an effect on these ice formation and retention processes. The formation of a stable ice cover is important throughout the Great Lakes/St. Lawrence System. The extended season might cause the ice to be rougher, thereby increasing retardation, or measures may be introduced which would reduce ice retardation. Should the navigation season extension cause a change in levels, there would be a redistribution of benefits to the navigation, power, and shore property interests. However, any impacts on levels and flows could be negated by modifications to the physical system and/or the Lakes Superior and Ontario operational regulation plans.

It should be noted that the analyses presented in this report are not to be considered as a prediction of possible future events but do show the conditions for a hypothetical range of impacts.

## SCOPE OF THE INVESTIGATION

The scope of this investigation was limited to the possible impacts on Great Lakes levels and flows for 10 and 12 month navigation above the Welland Canal and to determine the feasible navigation period below Lake Erie.

To establish the broadest range of impacts that could conceivably occur, to insure consideration of this range in the current feasibility analysis, and to set the stage for a more detailed analysis, as necessary in the future, the study has:

a. Determined the possible effects on the levels and flows of the system from a range of possible changes in ice retardation resulting from changes in historic ice retardation assuming no physical change in capacities of the system;

b. Determined the potential change in frequency of occurrerce of levels below Lower Water Datum (LWD) under a. above;

c. Determined the potential effect on the St. Lawrence River of a change in the river ice roughness, a change in the river ice thickness and of ice dams;

d. Identified additional modifications to the physical system and/or the operational regulation plans on Lakes Superior and Ontario required to minimize or eliminate the impacts determined above; and,

e. Analyzed the effects of a. and b. above on the water intakes for the power plants along the St. Clair and Detroit Rivers.

The possible impacts have been measured as a change in lake elevation or a change in levels and flows in the outlet channels with respect to a Base Case. The Base Case was derived using the inputs listed in the following section entitled "Basic Data." In order to reflect the current regime of the Great Lakes-St. Lawrence System, the 1960-1978 historic period was selected to represent Base Case, as this period most accurately reflects the present conditions. The period of record data (1900-1978) is presented as a back-up analysis. The earlier data were not used as the primary comparison base because, given the historic meteorological and hydrological conditions and the current Great Lakes outlet conditions, the period of record ice retardations and levels would not have been reproduced.

## BASIC DATA

The January 1900 - June 1973 basic data employed in this study are identical to the data documented in the 7 December 1973 Report of the International Great Lakes Levels Board to the International Joint Commission for the following parameters:

a. Monthly mean net basin supplies for Lakes Superior, Michigan-Huron and St. Clair;

b. Quarter month mean net basin supplies for Lakes Erie and Ontario;

c. Monthly mean ice and weed retardation values for the St. Clair and Detroit Rivers; and,

d. Quarter month mean differences between Lake St. Louis outflow and Lake Ontario outflow.

A detailed description of the development of the above data is given in Volume 2 of Appendix "B" of the 1973 Levels Board Report. The period was extended from July 1973 through December 1978 utilizing data coordinated with Environment Canada.

The Niagara River ice and weed retardation values are the average values reported in Section 24 of the Lake Erie Outflow 1860-1964 with Addendum 1965-1975 Report by the Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data, June 1976.

ASSUMPTIONS

The following assumptions were employed:

a. Regulation of Lake Superior was conducted on a monthly basis in accordance with the 1955 Modified Rule of 1949, as described in U.S. Army Corps of Engineers Miscellaneous Paper 67-1 "Control of Great Lakes Water Levels;"

b. 1962 outlet conditions for Lakes Michigan-Huron and St. Clair;

c. 1953 outlet conditions for Lake Erie (Niagara River);

d. Plan 1958-D (without any deviations from the plan) was applied on a quarter-month basis to regulate Lake Ontario (described in detail in the Plan 1958-D Report and the Operational Guides for Plan 1958-D Report to the International Joint Commission, by the International St. Lawrence River Board of Control, 12 December 1963);

e. For the Great Lakes routing model, only the ice retardation values of the St. Clair and Detroit Rivers for the navigation season in question were changed as a recult of extended season;

f. In determining the possible impact of changing ice retardation on the levels of Lakes Michigan-Huron and Erie, it was assumed that the same percentage change in retardation would occur simultaneously in both the St. Clair and Detroit Rivers. In this study, the effect of retardation was varied from total elimination (0% retardation) to doubling its effect (200% or twice what was experienced). Over the 1960-1978 period, the actual effect of ice retardation on the flow of the St. Clair River varied from no effect to a 63,000 cfs reduction in the rate of flow. On the Detroit River, ice retardation effects on the flow varied from no effect to a 44,000 cfs reduction;

g. The Long Lake-Ogoki Diversions were assumed at a constant 5,000 cubic feet per second (cfs);

h. The Lake Michigan Diversion at Chicago, Illinois, was assumed at a constant 3,200 cfs;

i. The Welland Canal was assumed at a constant flow of 7,000 cfs;

j. Ice retardation in the St. Marys River was assumed to be zero. This is based upon observation of no measurable retardation in that river during the extended season demonstration program. This is because the total river discharge is controlled at the head of the river and all releases are made through a number of structures; and,

k. In conducting the St. Lawrence River sensitivity analysis, a uniform ice cover 12 inches thick was assumed for the river in the initial phase of this study, except for the American Narrows and the reaches immediately downstream of the Ogdensburg-Prescott and Galop ice booms and Iroquois Dam, which were assumed to be ice free.

## APPROACH TO DETERMINING IMPACTS

The recorded levels of the Great Lakes-St. Lawrence River System reflect a balance of water supply to the lakes and that which flows through their outlet channels. Vessels moving through lake ice fields will not affect the total water supply nor the flow in the outlet channels. Hence, there would be no effect on the levels and flows of the Great Lakes if the extended season were confined to travel within a lake. However, vessel movement has not been confined to lake traffic but includes the outlet channels. To analyze the possible effect of movement of vessels through the ice fields in the Connecting Channels and the St. Lawrence River, it was hypothesized that the carrying capacities of these channels (under ice conditions) would either be improved or be further hindered due to changes in ice conditions. To define the range of impact of this possible variance on lake levels and flows, the historic ice retardation values on the St. Clair and Detroit Rivers were varied from total elimination of all ice effects to that of doubling the effect. Although this range in effects was selected for study, it is not to be implied that they might necessarily reach these proportions. Doubling the effects of ice was selected as a maximum for this study since utilizing values greater than twice the historic retardation resulted in unreasonable hydraulic conditions in the system (higher water levels on Lake St. Clair than on Lakes Michigan-Huron). The results of these variations in ice retardation were converted to impacts on levels and flows by routing these changes in water supply through the system. The period selected for primary analysis was 1960-1978, since this period most closely represents what would result in the future under a given set of meteorological conditions. The 1900-1978 period was also analyzed.

The evaluation of the impacts of the extended season on the St. Lawrence River utilized a mathematical model. In the calibration of the St. Lawrence River mathematical model, the thickness and roughness of the ice cover had to be considered. Employing the available data, it was assumed that the average thickness of ice was 12 inches and expected roughness factors could vary from 0.010 (a very smooth cover) to 0.030 (a very rough cover) with the average value being 0.014. The extremes of ice roughness used in this study were from 0.005 to 0.030. It should be noted that the ice covers on which the model was calibrated were established when vessel traffic was minimal or non-existent during the ice formation and consolidation phases. To determine impacts, utilizing this model, two evaluations made for the 1960-1978 period were:

a. Determination of the impact (sensitivity) of changing the ice roughness on the profile of the St. Lawrence River; and,

b. Determination of the impact (sensitivity) of changing ice thickness on the profile of the St. Lawrence River.

In all cases, where possible impacts on levels and flows were identified in the above analyses, additional remedial measures were proposed. Potential measures to offset these impacts consist of dredging in specific areas of the outlet channels, ice control structures, compensating works, and/or modification to the regulation plans for Lakes Superior and Ontario. Cost for these measures were included. A range of possible impacts on levels and flows is included for both the 1960-1978 and 1900-1978 periods. However, remedial measures are provided for the 1960-1978 period only.

## ASSESSMENT OF IMPACT WITH ASSOCIATED REMEDIAL MEASURES

The assessment presented herein of the possible impacts on the Great Lakes-St. Lawrence River System has been made on a geographical basis. As a result of the possible impacts which have been identified, remedial measures were designed and preliminary costs determined.

### Lakes Superior, Michigan-Huron, and Erie

Any extension of the navigation season traffic traveling only in the Lake Superior-St. Marys River-Lakes Michigan-Huron System would have no significant impact on the levels and flows of the Great Lakes-St. Lawrence River System. This is based upon the actual observed conditions which existed during the previous seven years of the Navigation Season Extension Demonstration Program for this system. No change in the measured levels, flows, occurrence of Low Water Datum or ice retardations were attributed to the Demonstration Program, and, therefore, similar future winter navigation would produce no impacts on levels and flows. As noted above, an ice boom has been installed in the St. Marys River to aid in maintaining an ice-free area at the head of Little Rapids Cut. Analysis of data obtained from monitoring river levels over the last three years at selected locations has indicated no impact on the outflows from Lake Superior resulting from the placing of this boom. Hence, there are no impacts on the Great Lakes levels or outflow regime and no change in the Lake Superior operational regulation plan would be necessary.

The proposed flushing of two of the U.S. locks at Sault Ste. Marie would not impact on water levels, and would reduce the water available for power during the winter navigation season by a negligible amount of 10 cfs (less than .02%).

Under this geographic scheme, some navigation, unless regulated, might transit the St. Clair River-Lake St. Clair-Detroit River system. Since this system is uncontrolled and the natural discharge relationships prevail, changes in the St. Clair and Detroit Rivers' ice retardation could possibly occur. This may produce impacts on the water levels and outflows of Lakes Michigan-Huron and Erie. Possible changes in the outflow of Lake Erie could eventually result in some impacts on the Lake Ontario water levels and outflows.

The hypothetical water level differences from Base Case for study, which assumed either the total elimination of ice retardation (0%) or double the historic ice retardation (200%) on the St. Clair and Detroit Rivers for 12-month navigation for both the 1960-1978 and 1900-1978 periods, are shown in Table 1. Based on the difference between the current regime (1960-1978) and the 1900-1959 regime (as noted previously), it was decided that the long-term data should not be utilized for remedial measures analyses. The theoretical 1960-1978 impact in any month of the study which assumed total elimination of ice retardation on the St. Clair and Detroit Rivers could lower the Lake Michigan-Huron level by 0.29 foot and could increase the Lake Erie level by 0.44 foot. The theoretical 1960-1978 impact in any month of doubling the historic ice retardation could raise the Lake Michigan-Huron level by 0.30 foot and could lower the Lake Erie level by 0.47 foot. The water level differences for the hypothetical ice retardations between these two extremes are plotted on Figure 13 for 12-month navigation.

The possible impacts of eliminating or doubling ice retardation on the St. Clair and Detroit Rivers on the 1960 to 1978 maximum, minimum, and average water levels of the Great Lakes system are shown in Table 2. This table shows that the possible impact of eliminating ice retardation on these rivers under a 12-month season extension could lower the Lake Michigan-Huron maximum, minimum, and average water levels by 0.16, 0.22 and 0.18 foot, respectively. The Lake

TABLE 1

MAXIMUM WATER LEVEL DIFFERENCES FROM BASE CASE
AS A RESULT OF POSSIBLE CHANGES IN ICE
RETARDATION ON THE ST. CLAIR AND DETROIT RIVERS
(FEET)

| | | LAKE MICHIGAN-HURON | | LAKE ERIE | |
|---|---|---|---|---|---|
| | | 10 Month | 12 Month | 10 Month | 12 Month |
| 1960-1978 | Max. | - .01 | - .01 | + .34 | + .44 |
| 0% Ice | Min. | - .18 | - .29 | .00 | .00 |
| Retardation* | Avg. | - .09 | - .18 | + .01 | + .02 |
| 1900-1978 | Max. | - .04 | - .04 | + .56 | + .90 |
| 0% Ice | Min. | - .28 | - .54 | .00 | .00 |
| Retardation* | Ave. | - .13 | - .31 | .00 | .00 |
| 1960-1978 | Max. | + .18 | + .30 | .00 | .00 |
| 200% Ice | Min. | + .01 | + .02 | - .36 | - .47 |
| Retardation* | Ave. | + .09 | + .18 | - .01 | - .02 |
| 1900-1978 | Max. | + .31 | + .57 | .00 | .00 |
| 200% Ice | Min. | + .04 | + .04 | - .60 | - .99 |
| Retardation* | Ave. | + .14 | + .33 | .00 | - .01 |

*Where 100% is the normal ice retardation
NOTE: These values represent the maximum, minimum, and average differences between any one month under Base Case and the exact same month under the adjusted ice retardation cases.

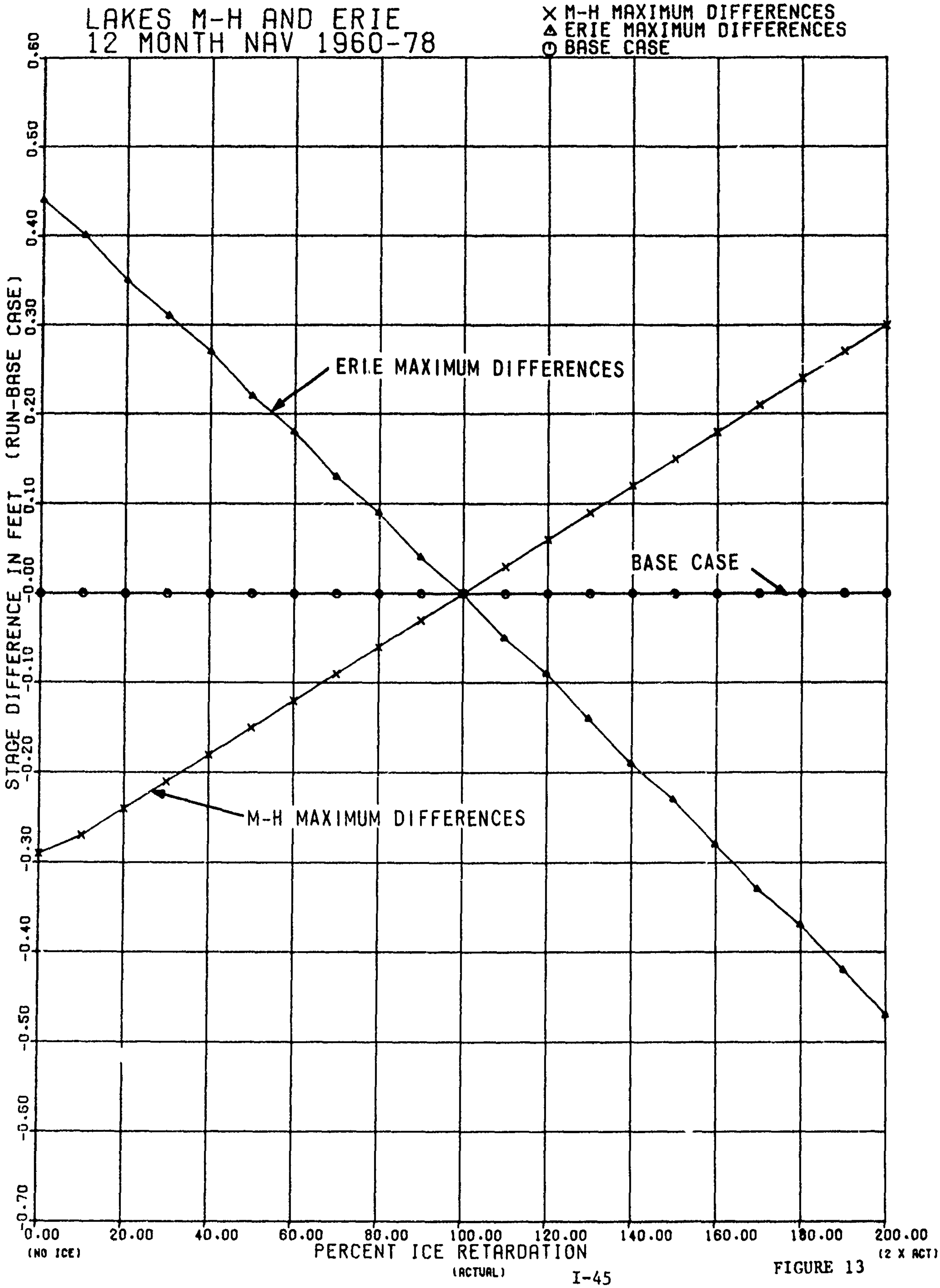

LAKES M-H AND ERIE
12 MONTH NAV 1960-78
M-H MAXIMUM DIFFERENCES
ERIE MAXIMUM DIFFERENCES
BASE CASE
STAGE DIFFERENCE IN FEET (RUN-BASE CASE)
0.60
0.50
0.40
0.30
0.20
0.10
-0.00
-0.10
-0.20
-0.30
-0.40
-0.50
-0.60
-0.70
ERIE MAXIMUM DIFFERENCES
BASE CASE
M-H MAXIMUM DIFFERENCES
0.00
(NO ICE)
20.00
40.00
60.00
80.00
100.00
(ACTUAL)
120.00
140.00
160.00
180.00
200.00
(2 X ACT)
PERCENT ICE RETARDATION

FIGURE 13

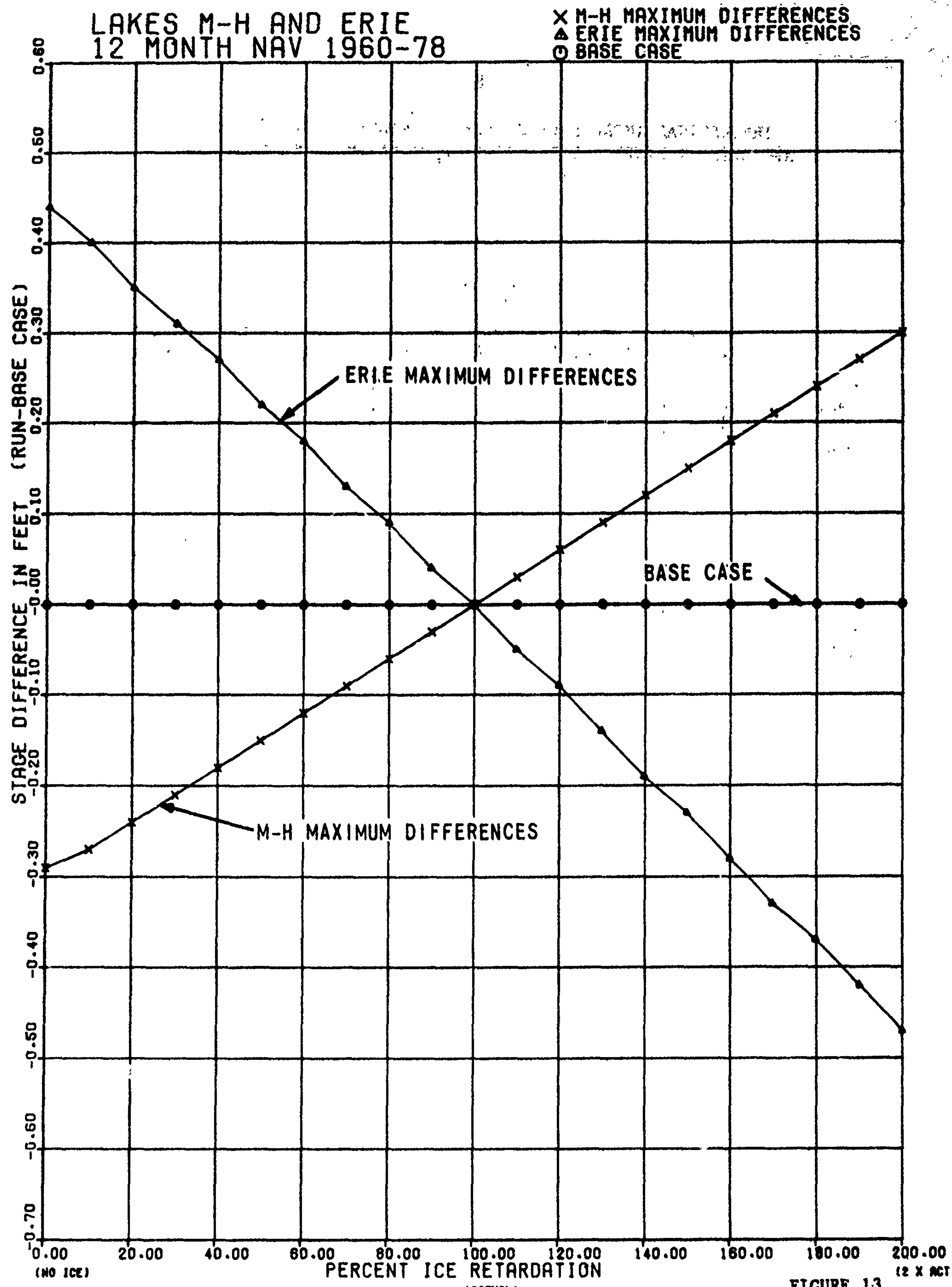

LAKES M-H AND ERIE
12 MONTH NAV 1960-78
× M-H MAXIMUM DIFFERENCES
△ ERIE MAXIMUM DIFFERENCES
⊙ BASE CASE
ERIE MAXIMUM DIFFERENCES
BASE CASE
M-H MAXIMUM DIFFERENCES
STAGE DIFFERENCE IN FEET (RUN-BASE CASE)
PERCENT ICE RETARDATION
(NO ICE)
(ACTUAL)
(2 X ACT
0.60
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
-0.60
-0.70
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00

FIGURE 13

TABLE 2

THEORETICAL IMPACTS OF POSSIBLE CHANGES IN ST. CLAIR AND DETROIT RIVER ICE RETARDATION ON MAXIMUM, MIMINUM AND AVERAGE WATER LEVELS (FEET)

(1960-1978)

LAKE MICHIGAN-HURON

| | BASE* CASE | 0% ICE RETARDATION 10 Month | 12 Month | 200% ICE RETARDATION 10 Month | 12 Month |
|---|---|---|---|---|---|
| Max. | 581.54 | 581.47 | 581.38 | 581.62 | 581.71 |
| Min. | 575.36 | 575.24 | 575.14 | 575.47 | 575.58 |
| Avg. | 578.60 | 578.51 | 578.42 | 578.69 | 578.78 |

LAKE ERIE

| | BASE CASE | 0% ICE RETARDATION 10 Month | 12 Month | 200% ICE RETARDATION 10 Month | 12 Month |
|---|---|---|---|---|---|
| Max. | 573.89 | 573.89 | 573.89 | 573.89 | 573.89 |
| Min. | 568.17 | 568.17 | 568.17 | 568.17 | 568.17 |
| Avg. | 571.19 | 571.20 | 571.21 | 571.18 | 571.17 |

LAKE ONTARIO

| | BASE CASE | 0% ICE RETARDATION 10 Month | 12 Month | 200% ICE RETARDATION 10 Month | 12 Month |
|---|---|---|---|---|---|
| Max. | 249.07 | 249.07 | 249.07 | 249.07 | 249.07 |
| Min. | 241.67 | 241.77 | 241.74 | 241.63 | 241.51 |
| Avg. | 245.38 | 245.38 | 245.38 | 245.38 | 245.38 |

*Base Case utilized actual (100%) ice retardations

NOTE: This table displays the maximum, minimum, and average values for each condition indicated.

Erie maximum and minimum water levels would not be altered, but the average level could be raised by 0.02 foot. Lake Ontario could be impacted due to possible changes in Lake Erie outflows and hence could have its minimum water level raised by 0.07 foot. The Lake Ontario maximum and average levels would not change. In the case where double ice retardation is assumed, the maximum, minimum, and average water levels of Lakes Michigan-Huron could be increased by 0.17, 0.22 and 0.18 foot, respectively. The Lake Erie maximum and minimum water levels would not be changed, but the average water level could be lowered by 0.02 foot. On Lake Ontario, the maximum and average levels would not change, but the minimum water level could decrease by 0.16 foot.

The maximum, minimum, and average outflows for Lakes Michigan-Huron and Erie that could result from routing the theoretical extreme ice retardation conditions (0% and 200%) on the St. Clair and Detroit Rivers through the systems are compared to the Base Case flows on Tables 3 and 4, respectively.

Extending the navigation season through 12-months could produce changes in the number of water level occurrences below LWD. These possible changes based upon the extreme ice retardation (0% and 200%) values for the St. Clair and Detroit Rivers are shown in Table 5.

Shown also on Tables 1 through 5 and on Figure 14 are values for navigation over a 10-month period. As shown, these possible impacts are about one-half of those identified for the 12-month period. However, it should be noted that the main report and Appendix B proposed that, if navigation is to be conducted on the St. Clair and Detroit Rivers as part of total navigation season extension, ice control at the head of the St. Clair and Detroit Rivers would be installed. If this is the case, then the possible impacts shown for ice retardation elimination over ten months is only a part of the 12-month effect and would be mitigated. In the case where

TABLE 3

LAKE MICHIGAN- HURON OUTFLOWS (1000 cfs)

1960 - 1978

| | | J | F | M | A | M | J | J | A | S | O | N | D | YEAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 Month Nav. | Max. | 216 | 205 | 207 | 215 | 225 | 231 | 235 | 237 | 236 | 233 | 229 | 222 | 237 |
| Season 0% Ice | Mean | 187 | 164 | 178 | 185 | 191 | 196 | 200 | 201 | 201 | 199 | 196 | 192 | 191 |
| Retardation | Min. | 152 | 126 | 140 | 148 | 151 | 155 | 157 | 159 | 160 | 160 | 158 | 156 | 126 |
| 12 Month Nav. | Max. | 215 | 211 | 206 | 212 | 222 | 229 | 233 | 236 | 235 | 231 | 227 | 220 | 236 |
| Season 0% Ice | Mean | 186 | 182 | 179 | 182 | 189 | 194 | 198 | 199 | 199 | 197 | 195 | 190 | 191 |
| Retardation | Min. | 150 | 146 | 143 | 144 | 148 | 152 | 155 | 157 | 158 | 158 | 157 | 154 | 143 |
| Base Case | Max. | 208 | 207 | 209 | 216 | 226 | 232 | 236 | 238 | 237 | 234 | 230 | 220 | 238 |
| | Mean | 169 | 167 | 180 | 187 | 194 | 198 | 201 | 202 | 202 | 200 | 197 | 188 | 190 |
| | Min. | 131 | 130 | 143 | 151 | 153 | 157 | 159 | 161 | 161 | 161 | 160 | 155 | 130 |
| 10 Month Nav. | Max. | 206 | 209 | 211 | 218 | 228 | 233 | 237 | 240 | 239 | 235 | 231 | 218 | 240 |
| Season 200% Ice | Mean | 152 | 170 | 183 | 188 | 196 | 200 | 203 | 204 | 203 | 201 | 198 | 185 | 190 |
| Retardation | Min. | 102 | 133 | 146 | 153 | 156 | 159 | 161 | 162 | 163 | 163 | 161 | 154 | 102 |
| 12 Month Nav. | Max. | 207 | 204 | 213 | 220 | 230 | 235 | 239 | 241 | 240 | 236 | 232 | 219 | 241 |
| Season 200% Ice | Mean | 153 | 151 | 182 | 191 | 198 | 202 | 205 | 206 | 205 | 203 | 200 | 186 | 190 |
| Retardation | Min. | 103 | 103 | 143 | 157 | 159 | 162 | 164 | 165 | 165 | 165 | 163 | 155 | 103 |

TABLE 4

LAKE ERIE OUTFLOWS (1000 cfs)

1960 - 1978

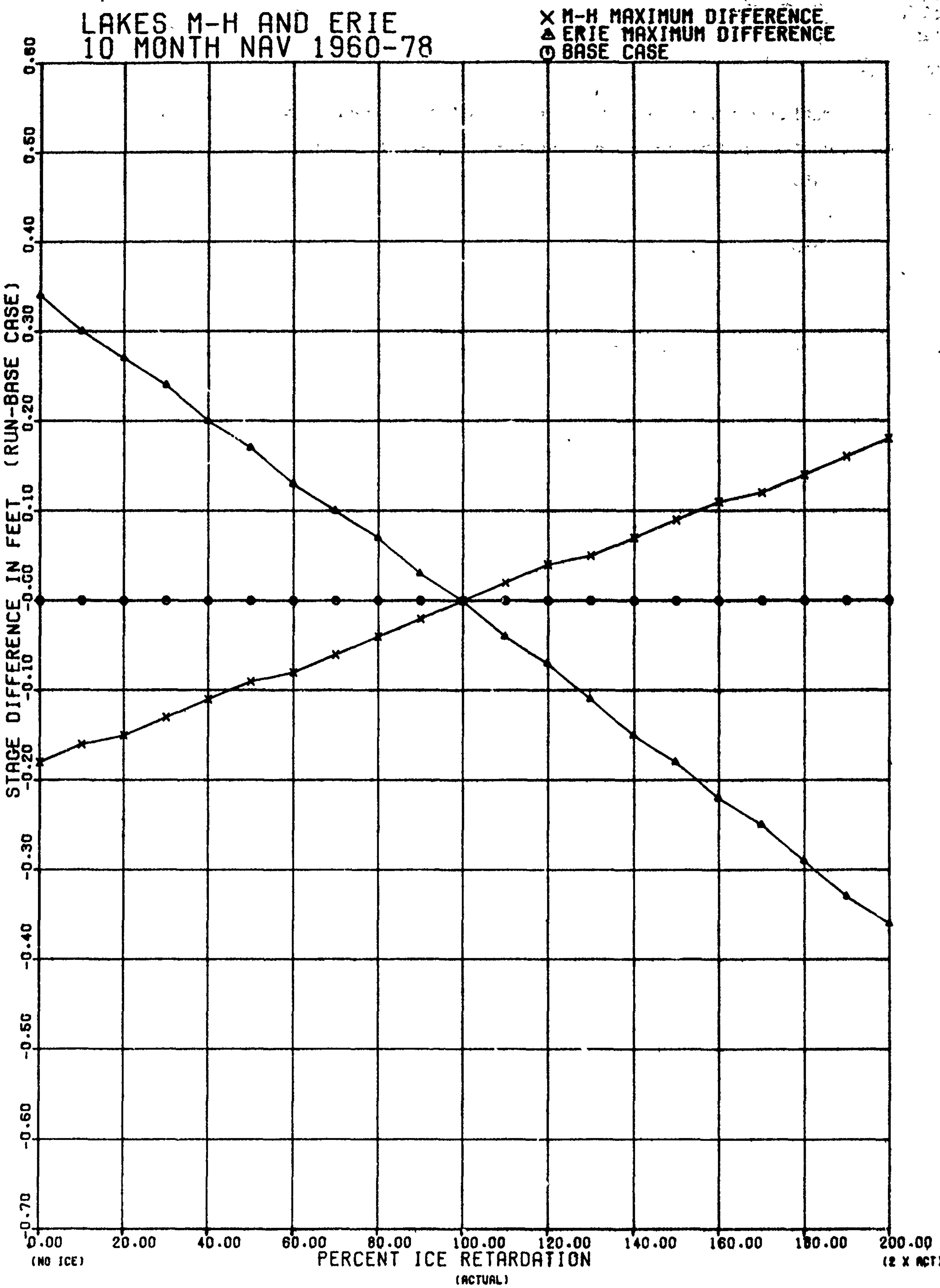
| | | J | F | M | A | M | J | J | A | S | O | N | D | YEAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 Month Nav. | Max. | 248 | 253 | 265 | 270 | 276 | 276 | 270 | 264 | 255 | 248 | 243 | 249 | 276 |
| Season 0% Ice | Mean | 206 | 207 | 215 | 221 | 231 | 230 | 225 | 221 | 217 | 211 | 208 | 209 | 217 |
| Retardation | Min. | 159 | 160 | 166 | 176 | 186 | 184 | 177 | 173 | 170 | 161 | 158 | 157 | 157 |
| 12 Month Nav. | Max. | 247 | 253 | 267 | 270 | 275 | 276 | 269 | 263 | 254 | 247 | 242 | 248 | 276 |
| Season 0% Ice | Mean | 205 | 208 | 217 | 223 | 232 | 231 | 225 | 221 | 216 | 211 | 207 | 209 | 217 |
| Retardation | Min. | 158 | 161 | 169 | 178 | 188 | 184 | 177 | 173 | 169 | 161 | 157 | 156 | 156 |
| Base Case | Max. | 249 | 253 | 265 | 270 | 276 | 277 | 271 | 265 | 256 | 249 | 244 | 250 | 277 |
| | Mean | 205 | 205 | 213 | 221 | 231 | 230 | 225 | 222 | 218 | 212 | 209 | 210 | 217 |
| | Min. | 158 | 157 | 164 | 175 | 186 | 183 | 177 | 174 | 170 | 162 | 159 | 158 | 157 |
| 10 Month Nav. | Max. | 250 | 252 | 264 | 270 | 277 | 278 | 272 | 266 | 257 | 250 | 246 | 252 | 278 |
| Season 200% Ice | Mean | 203 | 202 | 212 | 220 | 230 | 230 | 225 | 223 | 218 | 213 | 210 | 211 | 216 |
| Retardation | Min. | 157 | 154 | 162 | 174 | 185 | 183 | 177 | 174 | 171 | 163 | 159 | 159 | 154 |
| 12 Month Nav. | Max. | 251 | 252 | 265 | 271 | 277 | 278 | 273 | 267 | 258 | 251 | 247 | 253 | 278 |
| Season 200% Ice | Mean | 204 | 201 | 209 | 218 | 229 | 230 | 225 | 223 | 219 | 214 | 211 | 212 | 216 |
| Retardation | Min. | 158 | 153 | 159 | 171 | 184 | 183 | 177 | 175 | 172 | 164 | 160 | 160 | 153 |

TABLE 5

NUMBER OF OCCURRENCES OF MONTHLY MEANS BELOW LOW WATER DATUM
AS A RESULT OF POSSIBLE CHANGES IN ICE RETARDATION ON THE
ST. CLAIR AND DETROIT RIVERS

1960 -1978

| | LAKE MICHIGAN-HURON | | | | | LAKE ERIE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Base Case | 10 Mo. 0% | 12 Mo. 0% | 10 Mo. 200% | 12 Mo. 200% | Base Case | 10 Mo. 0% | 12 Mo. 0% | 10 Mo. 200% | 12 Mo. 200% |
| J | 3 | 3 | 4 | 3 | 3 | 2 | 2 | 2 | 2 | 2 |
| F | 3 | 4 | 4 | 3 | 3 | 2 | 1 | 1 | 2 | 2 |
| M | 3 | 3 | 3 | 3 | 3 | 0 | 0 | 0 | 1 | 1 |
| A | 3 | 3 | 3 | 3 | 2 | 0 | 0 | 0 | 0 | 0 |
| M | 2 | 3 | 3 | 2 | 2 | 0 | 0 | 0 | 0 | 0 |
| J | 2 | 2 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| J | 2 | 2 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| A | 2 | 2 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| S | 2 | 3 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| O | 2 | 2 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 |
| N | 2 | 3 | 4 | 2 | 2 | 1 | 1 | 1 | 1 | 1 |
| D | 3 | 3 | 4 | 3 | 2 | 2 | 2 | 2 | 2 | 1 |
| TOTAL | 29 | 33 | 40 | 28 | 23 | 8 | 7 | 7 | 9 | 8 |



LAKES M-H AND ERIE
10 MONTH NAV 1960-78
X M-H MAXIMUM DIFFERENCE
▲ ERIE MAXIMUM DIFFERENCE
⊙ BASE CASE
STAGE DIFFERENCE IN FEET (RUN-BASE CASE)
0.60
0.50
0.40
0.30
0.20
0.10
-0.00
-0.10
-0.20
-0.30
-0.40
-0.50
-0.60
-0.70
0.00
(NO ICE)
20.00
40.00
60.00
80.00
100.00
(ACTUAL)
120.00
140.00
160.00
180.00
200.00
(2 X ACT)
PERCENT ICE RETARDATION




FIGURE 14

navigation would not be extended beyond 10 months (without an ice control structure), then the possible effect would be as shown in Table 2. However, navigation, in fact, has operated in that part of the system into and through January over the last few years. To date, the impact has been less than the maximums shown on Table 2, as reflected in Figure 11. Hence, it can be concluded that extension of the season through 10 months above the Welland Canal would have little or no impact on the Great Lakes levels and flows regime.

To offset the possible effects of total elimination of ice retardation, partial control works would be required in the St. Clair and Detroit Rivers. To offset the possible effects of twice the historic ice retardation, dredging and control works would be required in both of these rivers.

In the case where the extreme condition of total elimination of ice retardation on the St. Clair and Detroit Rivers is assumed, a structure would have to be placed in each of these rivers to restore the flows to what they would have been had ice retardation not been reduced or totally eliminated. As noted previously, ice problems in the St. Clair River result from lake ice jamming in the lower reaches of the river, the degree of which is unpredictable from year to year. The conceptional remedial measures presented herein have been developed to offset the extreme effect shown on Table 1, but would be operated to offset average conditions and provide as near normal fluctuations as possible. The structures would allow for flow retardation during periods when ice retardation would normally have occurred, but during ice-free months would be operated to permit the normal stage-discharge relationships to exist. Such operation would offset any effect on levels and flows resulting from changes in ice retardation on the St. Clair and Detroit Rivers noted in this report.

For the purpose of this report, the location and design of the structures have been selected based on the information presented in

Appendix G of the 1973 International Great Lakes Levels Board Report to the International Joint Commission on the "Regulation of Great Lakes Water Levels." The optimum locations for these structures were determined from St. Clair and Detroit River Mathematical Models developed for the 1973 study. The engineering studies necessary to prepare the design for these structures were provided by a contractor and were based upon geotechnical field data and river hydraulics as provided by the Mathematical Models. From the information presented in Table 2, it has been determined that the structures may require the ability to retard flows by an average amount during the winter period of up to 12,000 cfs on the St. Clair River and 9,000 cfs on the Detroit River.

The sites currently selected for the structures necessary for maintenance of the levels and flows on the Great Lakes, as a result of assumed total elimination of ice retardation in the St. Clair and Detroit Rivers, are at Stag Island in the St. Clair River and Peach Island in the Detroit River. The preliminary project costs for these structures are presented in Appendix B.

In the case where twice the historic ice retardation on the St. Clair and Detroit Rivers is assumed, a more complex problem occurs. Dredging may be required to offset the possible effect of the increased ice retardation and structures may be required to offset the effects of this dredging during the ice-free months.

However, as noted previously, if extended navigation is contemplated on the St. Clair and Detroit Rivers, an ice control structure would be placed at the head of the St. Clair and Detroit Rivers. This precludes the assumption of increased ice retardation and, therefore, conceptional mitigation for this occurrence has not been developed. Therefore, dredging of the St. Clair or Detroit Rivers is not proposed for the Extended Season Navigation Program.

With respect to the water intakes on the St. Clair and Detroit Rivers, a detailed analysis of the impacts due to extended navigation has not been made. However, from an analysis of the upstream and downstream stages, there would be no significant impact on the profile of either river and, therefore, no major impact on these facilities. There could be some minor impact on pumping costs.

Entire Great Lakes-St. Lawrence River System

Impacts and remedial measures for this geographic area would be the same for Lakes Superior, Michigan-Huron and Erie as stated above with the exception that when the entire system is considered, the Welland Canal is included, and it could experience an increased flow during extended navigation periods. Based upon the previous 15 years of flow through the Welland Canal, this could result in an ultimate reduction in the water level of Lake Erie by amounts less than 0.10 foot. To offset this possible impact would require a reduction in water usage throughout the balance of the navigation season. This reduction would approximate 100 cfs. Since existing works in the Welland Canal have the capability to make this adjustment, no additional remedial works would be necessary.

The proposed flushing (up to 2,000 cfs) of two of the St. Lawrence River locks (Eisenhower and Snell) would not impact on water levels. However, it should be noted that any water utilized for flushing would reduce the water available for power production by an equal amount (less than one percent).

The maintenance of Low Water Datum (LWD) on the St. Lawrence River would be necessary to allow for full draft for navigation of the entire river. The current regulation scheme does not contemplate navigation on the St. Lawrence River past 15 December. As a result, Low Water Datum (LWD) is not necessarily maintained past this date. Since winter 1959-60, the St. Lawrence River has experienced water

levels below LWD for all but three years. On the average* the river dropped below LWD in the second week of January of each year and remained below LWD until the second week of March. This navigation problem could be resolved by:

a. Reduction in the regulated outflows coupled with the necessary regulation changes in the downstream (Canadian only) portion of the river and/or;
b. Dredging and/or;
c. Installation of additional ice control structures.

The existence of St. Lawrence River water levels below LWD (as much as 4 feet below) are for the most part a consequence of the major navigation constraint to extended season navigation on the St. Lawrence River, that of hanging ice dams. The series of ice control structures and dredging in areas of critically high velocities are proposed for the St. Lawrence River and are intended to remove the ice dam constriction to allow for winter navigation to proceed on the St. Lawrence River. Removal of this constriction would significantly increase the winter conveyance of the International Rapids Section of that river which would allow higher Lake St. Lawrence water levels. On the average these structures and dredging would preclude the occurrence of water levels below LWD and would all but eliminate the need for implementing proposal a. above.

The water level of Lake Ontario could be impacted by the sensitivity of ice retardation to ship passages through the ice in the St. Lawrence River. The sensitivity analysis simulated what possible impacts on the water level profile of the St. Lawrence River, assuming no physical change in the current capacity, may occur as a result of ship movement through the ice cover. The possible impacts on the river profile would result from changes in ice roughness and/or ice thickness.

*The mean median and mode for the past 19 years is 7 January.

The sensitivity of the St. Lawrence River water level profile to variances in ice roughness has been evaluated by two methods:

Method 1 simulated the impact on the St. Lawrence River water level profile of change in fall with respect to change in ice roughness. These effects were computed for a representative range of winter flows of 270, 240, and 210 thousand cubic feet per second (TCFS). The results of this study are shown in Figures 15-17.

Method 2 held the Lake Ontario water level constant and varied the ice cover roughness at a constant river flow of 245 TCFS. The simulated impact of changing the river ice roughness from 0.005 to 0.030 reduced the water level at Lake St. Lawrence as shown on Figure 18. It should be noted that during the calibration of the St. Lawrence River flow model the average river ice roughness was determined to be 0.014.

To minimize adverse changes in ice roughness, it is suggested that winter navigation should, on the average, not proceed on the St. Lawrence River during the ice formation period. Based upon the data for the winters since 1960, the average duration of this ice formation period on the International Section of the St. Lawrence was 23 days. For the 11 years (out of 18) when evidence of a specific ice formation period existed, the average date for the beginning of this period was 7 January. The longest duration of ice formation was 73 days and the earliest starting date for ice formation was 24 December (both occurred in winter 1976-77).

The sensitivity of the St. Lawrence River water level profile to variances in ice thickness has been evaluated by two methods:

Method 1 simulated the impact on the St. Lawrence River water level profile of a change in the ice thickness over the entire river. Using a Lake Ontario elevation of 241.78 with a St. Lawrence River flow of 183,000 cfs (low), 244.20 with a 236,000 cfs flow (average)

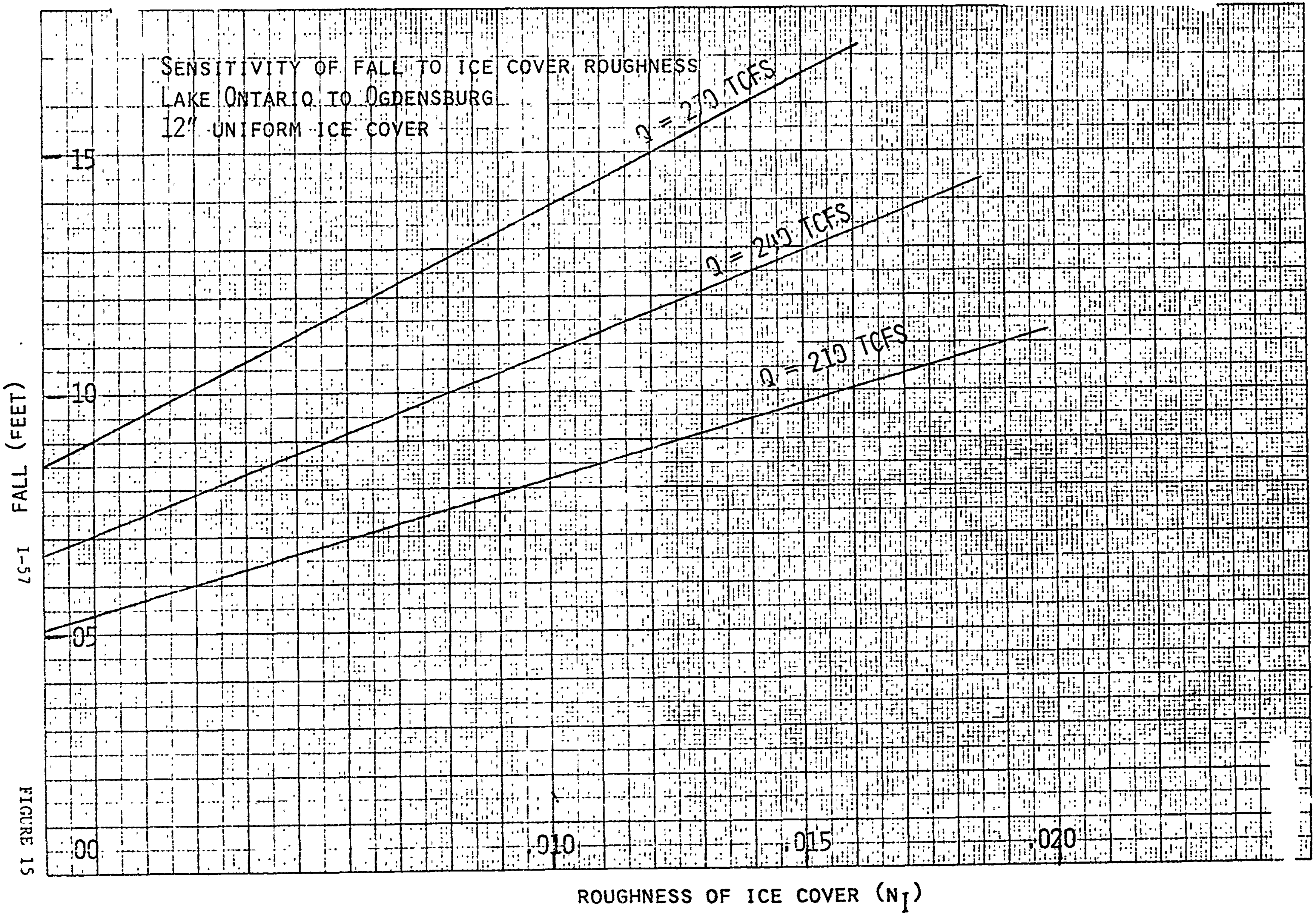

SENSITIVITY OF FALL TO ICE COVER ROUGHNESS
LAKE ONTARIO TO OGDENSBURG
12" UNIFORM ICE COVER
Q = 270 TCFS
Q = 240 TCFS
Q = 210 TCFS
15
10
05
00
.010
.015
.020
FALL (FEET)
ROUGHNESS OF ICE COVER ($N_I$)

FIGURE 15

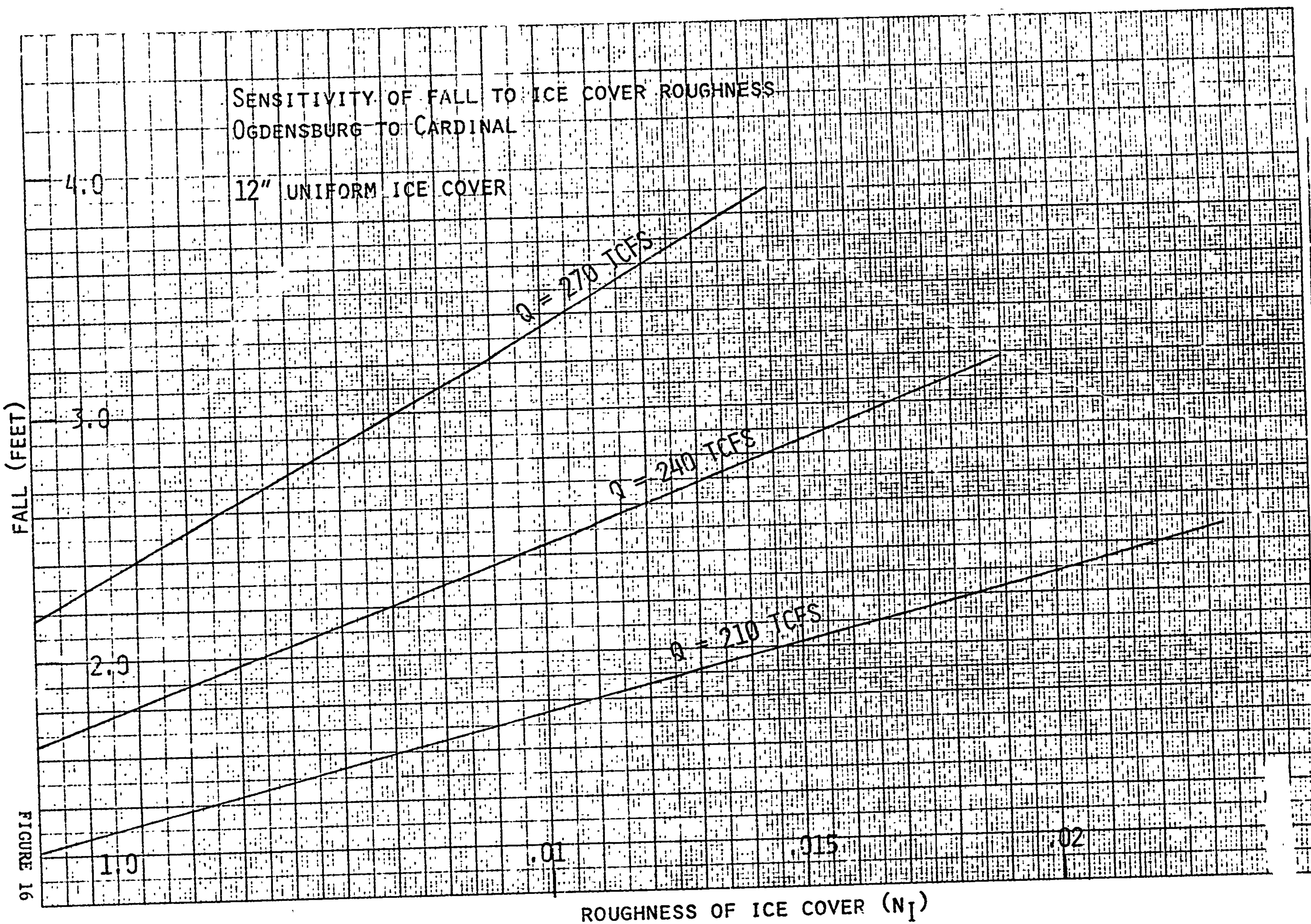

SENSITIVITY OF FALL TO ICE COVER ROUGHNESS
OGDENSBURG TO CARDINAL
12" UNIFORM ICE COVER
Q = 270 TCFS
Q = 240 TCFS
Q = 210 TCFS
4.0
3.0
2.0
1.0
FALL (FEET)
.01
.015
.02
ROUGHNESS OF ICE COVER ($N_I$)

FIGURE 16

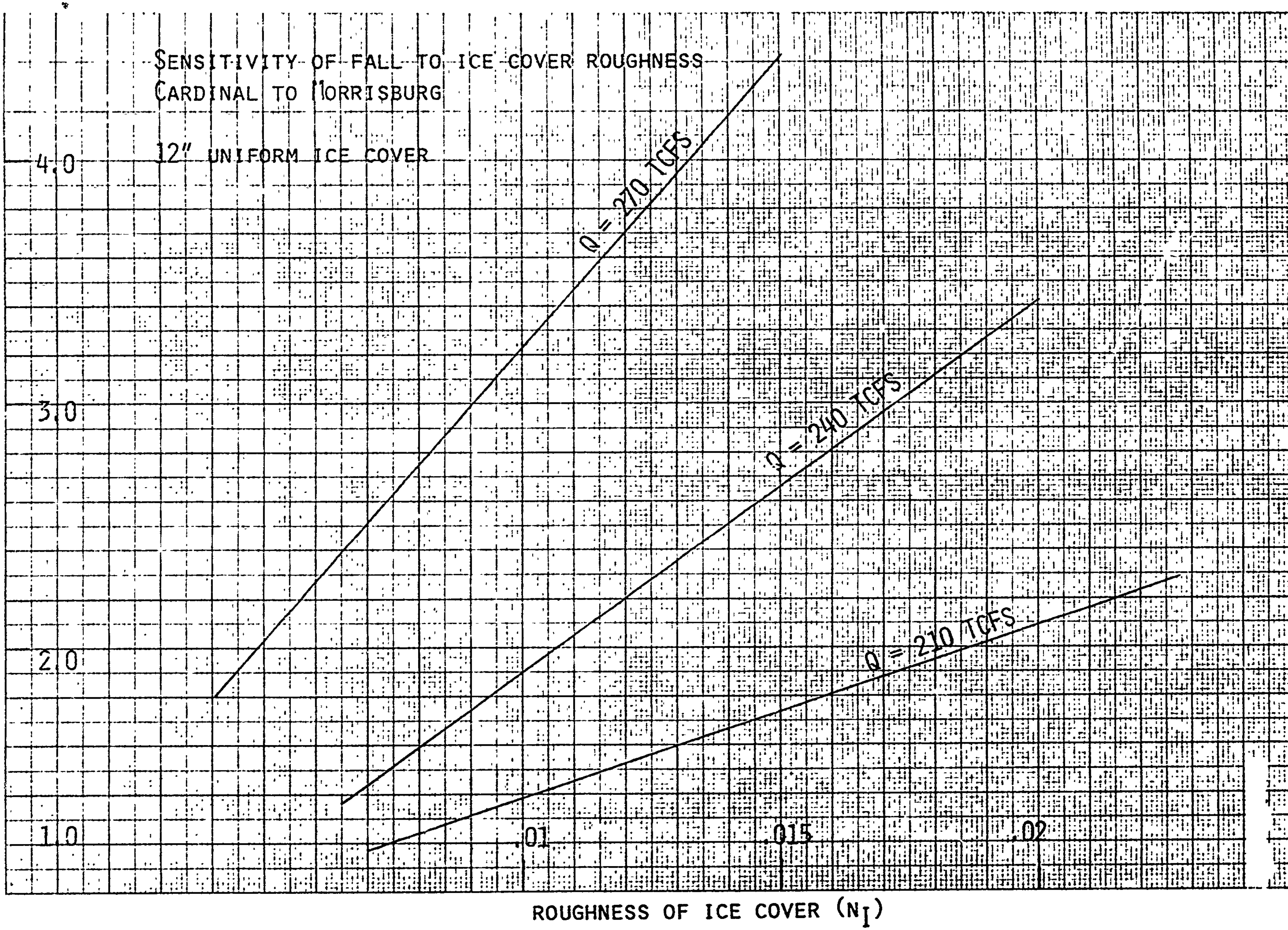
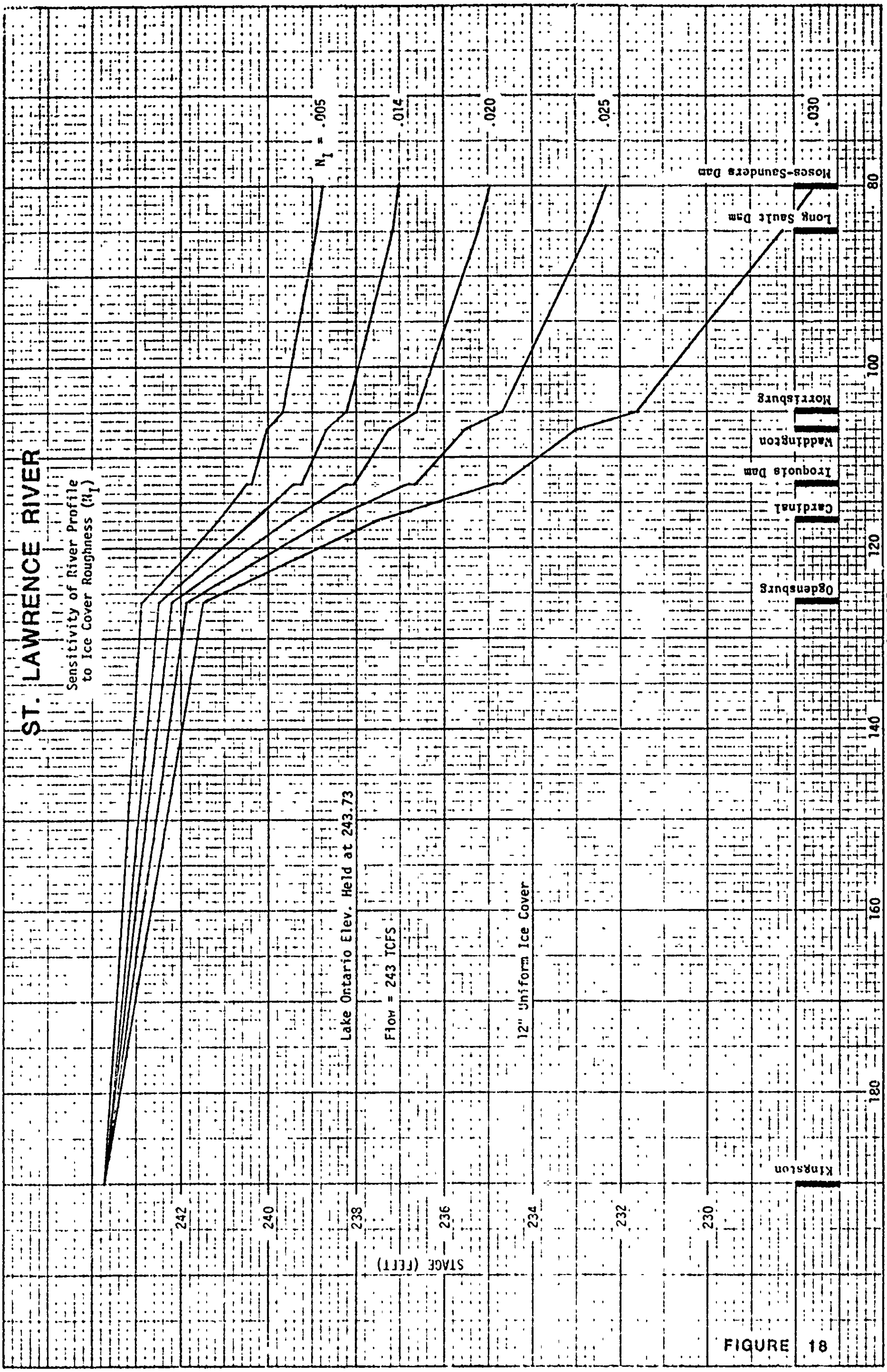

SENSITIVITY OF FALL TO ICE COVER ROUGHNESS
CARDINAL TO MORRISBURG
12" UNIFORM ICE COVER
Q = 270 TCFS
Q = 240 TCFS
Q = 210 TCFS
4.0
3.0
2.0
1.0
FALL (FEET)
.01
.015
.02
ROUGHNESS OF ICE COVER ($N_I$)

FIGURE 17



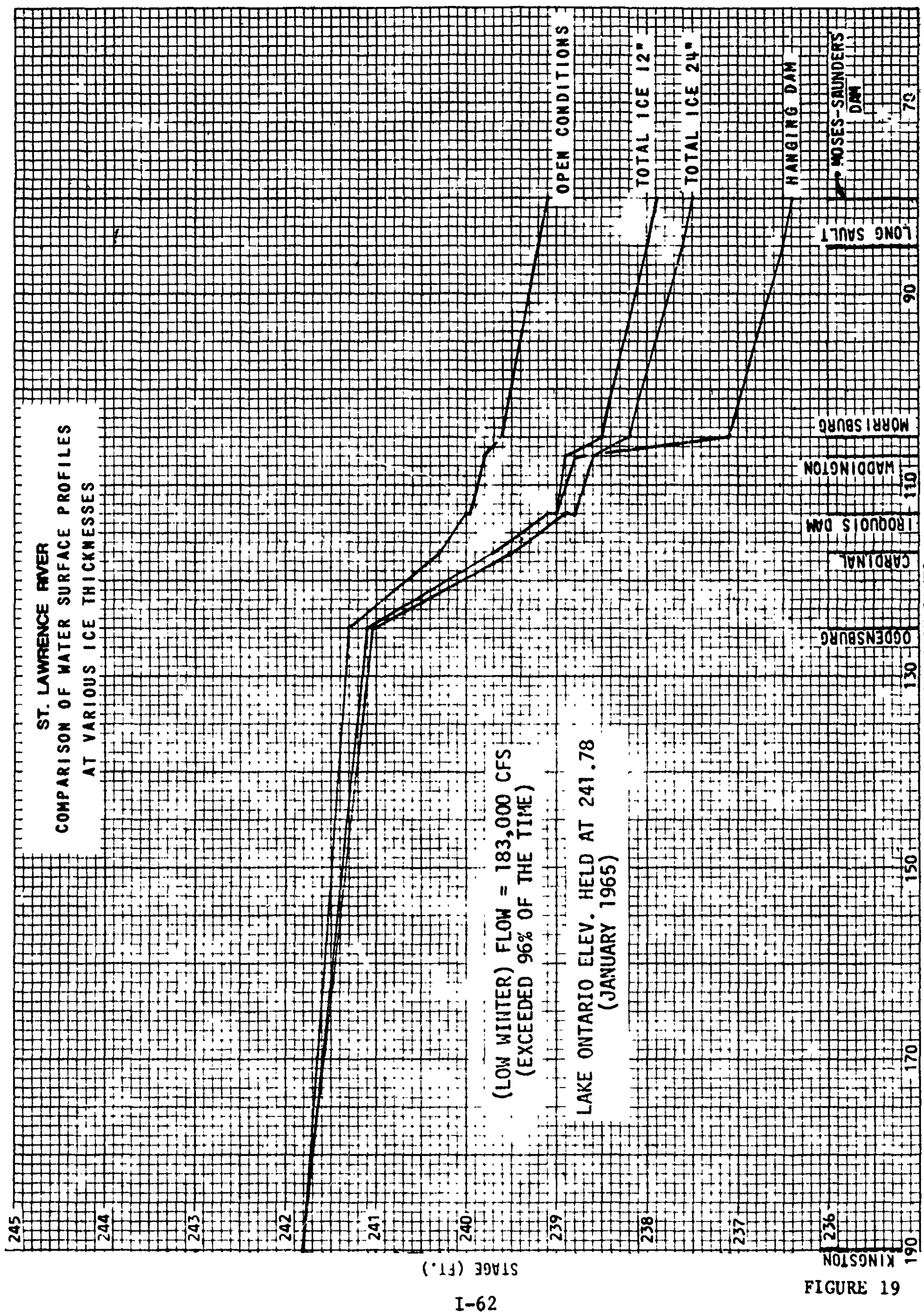
ST. LAWRENCE RIVER
Sensitivity of River Profile to Ice Cover Roughness ($N_I$)
Lake Ontario Elev. Held at 243.73
Flow = 243 TCFS
12" Uniform Ice Cover
$N_I$ = .005
.014
.020
.025
.030
Moses-Saunders Dam
Long Sault Dam
Morrisburg
Waddington
Iroquois Dam
Cardinal
Ogdensburg
Kingston
80
100
120
140
160
180
MILES ON RIVER
242
240
238
236
234
232
230
STAGE (FEET)


FIGURE 18

and 245.05 with a 289,000 cfs flow (high), profiles were computed for open water conditions, for a uniform 12 inch ice cover and for a uniform 24 inch ice cover. Plots of the profiles obtained for low, average, and high flow conditions are shown in Figures 19, 20, and 21, respectively. These figures show that, while holding Lake Ontario and the river flow constant, a uniform one foot ice cover over the river could lower the water level at Lake St. Lawrence by as much as 3.29 feet under a high flow condition when compared to open water conditions. Increasing the river ice thickness from one to two feet could reduce the water level of Lake St. Lawrence by an additional 1.16 feet under a high flow condition.

Method 2 simulated the impact on the profile of the St. Lawrence River of a hanging ice dam in the north channel around Ogden Island. The dam was assumed to be 30 feet in depth with a length of 1,300 feet (similar ice conditions have been known to exist), while the remainder of the river was assumed at a uniform 12 inch cover. This hanging dam effect on the profile of the St. Lawrence River for the average and low flows is also shown in Figures 19 and 20. With a hanging dam of these proportions, the high flow (289,000 cfs) could not be realized due to the large reduction in channel capacity at the dam. Figure 19 shows that the hanging dam under average flow condition could produce a 2.45 foot decrease in the water level of Lake St. Lawrence from the level computed for a uniform 12 inch ice cover. To greatly reduce or totally eliminate the possibility of the occurrence of a hanging dam in order to allow ship passage, it is necessary to create a condition conducive to the formation of a stable ice cover upstream of the hanging dam area (Cardinal to Ogden Island reach). This could be accomplished by the following:

a. Utilization of a series of ice control structures. This scheme was developed by the St. Lawrence Seaway Development Corporation (SLSDC) in the 1975 "St. Lawrence Seaway System Plan for All-year Navigation" (SPAN) Report. Those structures, if effective



ST. LAWRENCE RIVER
COMPARISON OF WATER SURFACE PROFILES
AT VARIOUS ICE THICKNESSES
(LOW WINTER) FLOW = 183,000 CFS
(EXCEEDED 96% OF THE TIME)
LAKE ONTARIO ELEV. HELD AT 241.78
(JANUARY 1965)
OPEN CONDITIONS
TOTAL ICE 12"
TOTAL ICE 24"
HANGING DAM
MOSES-SAUNDERS DAM
LONG SAULT
MORRISBURG
WADDINGTON
IROQUOIS DAM
CARDINAL
OGDENSBURG
KINGSTON
MILES ON RIVER
STAGE (FT.)


FIGURE 19

# APPENDIX J

## LEGAL CONSIDERATIONS

# APPENDIX J

## REPORT OF THE LEGAL COMMITTEE TO THE WINTER NAVIGATION BOARD

## LEGAL CONSIDERATIONS ASSOCIATED WITH AN EXTENSION OF THE NAVIGATION SEASON IN THE GREAT LAKES SYSTEM AND THE ST. LAWRENCE SEAWAY

August 28, 1978

CONTENTS

Attachments

## I. Introduction

In 1970 the Congress authorized the Corps of Engineers in cooperation with other interested federal agencies to undertake a program to demonstrate the practicability of extending the navigation season on the Great Lakes and St. Lawrence River. After the inception of the demonstration program, it became apparent that some of the proposals to demonstrate an extended navigation season were viewed with concern by those entities [1/] which had developed the hydroelectric power potential of the International Rapids Section of the St. Lawrence River. The principal concern of the power entities is that flows in the St. Lawrence River could no longer be adequately regulated if the stable ice cover, which is formed annually with the assistance of ice booms, were disturbed by winter navigation.

One of these entities, the Power Authority of the State of New York, (PASNY) stated that any interference with the ability to control flows could cause flooding upstream on the river and on Lake Ontario and could also curtail power output at the St. Lawrence Projects of Ontario-Hydro and PASNY and downstream at Hydro Quebec's Beauharnois Station. PASNY advised that it is opposed to any demonstration program activities which interfere with its ability to control flows by disrupting existing ice control procedures, such as the transit by vessels of the ice booms jointly operated by PASNY and Ontario-Hydro, until certain questions concerning its rights, liabilities, and responsibilities are satisfactorily resolved.

As a result, a Legal Committee was established to consider the problems presented by PASNY, as well as those affecting riparian and other

1/ Power Authority of the State of New York and Ontario-Hydro.

interests, and to advise the Winter Navigation Board as to the rights and liabilities of the United States with respect to an extended navigation season.

## II. The Winter Navigation Program

The River and Harbor Act of 1970 authorizes a Winter Navigation Program consisting of a Survey Study, a Demonstration Program and an Insurance Study Program.[2/] Section 107(b) thereof provides:

> "The Secretary of the Army, acting through the Chief of Engineers, in cooperation with the Departments of Transportation, Interior, and Commerce, including specifically the Coast Guard, the Saint Lawrence Seaway Development Corporation, and the Maritime Administration; the Environmental Protection Agency; other interested Federal agencies, and non-Federal public and private interests, is authorized and directed to undertake a program to demonstrate the practicability of extending the navigation season on the Great Lakes and Saint Lawrence Seaway. Such program shall include, but not be limited to, ship voyages extending beyond the normal navigation season; observation and surveillance of ice conditions and ice forces; environmental and ecological investigations; collection of technical data related to improved vessel design; ice control facilities, and aids to navigation; physical model studies; and coordination of the collection and dissemination of information to shippers on weather and ice conditions." 3/

The ultimate goal is to demonstrate the feasibility and practicability of extending the navigation season on the Great Lakes System and the Saint Lawrence Seaway through tests of new and innovative methods of facilitating ship movements while minimizing any concurrent adverse effects.

The organizational structure of the Demonstration Program was established under the terms of a Memorandum of Understanding signed by the

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2/ Pub.L. No. 91-611, 84 Stat. 1818, as amended by Pub. L. No. 93-251, §70, 88 Stat. 12 and Pub. L. No. 94-587, §107, 90 Stat. 2923.

3/ Id. §107(b).

participating agencies. The memorandum provides for the establishment of a Winter Navigation Board (WNB) composed of senior field representatives of participating federal agencies and other invited organizations. The WNB provides overall planning, programming, budgeting, and approval for execution and reporting of investigations and demonstration activities.

A Working Committee, similarly constituted, provides continuous coordination of program activities as approved by the WNB. Seven independent work groups conduct all the activities undertaken for the program.

The work groups report to and receive guidance from the Working Committee which carries out program activities approved by the WNB. The Working Committee consists of the regional, advisory, and observer groups.

The Working Committee functions at a level between the WNB and the work groups. It makes specific recommendations to the WNB as a result of work group activities and in turn implements WNB directives through the work groups, develops priorities from among group activities, proposes distribution of allocated funds, and provides the vehicle for the input of ideas and opinions from regional and advisory groups. The work groups are responsible for carrying out activities under each of these seven functional elements: Ice Information; Ice Navigation; Ice Engineering; Ice Control; Ice Management in Channels, Locks, and Harbors; Economic Evaluation; and Environmental Evaluation.

Several legal questions were raised by proposals to demonstrate the practicability of extending the navigation season in the Great Lakes System and on the St. Lawrence River. Consequently, on October 22, 1974, the WNB created a Legal Committee to assist it in considering potential legal problems.

The Legal Committee was composed of the following:

Mr. Arthur Ernstein, Division Counsel, North Central Division, U.S. Army Corps of Engineers (Chairman);

Mr. Frederick A. Bush, General Counsel, Saint Lawrence Seaway Development Corporation;

Mr. Bruce C. McLean, Counsel, Power Authority of the State of New York;

Mr. John A. McWilliam, representing the ports of the Great Lakes.

In addition to its own deliberations, the Legal Committee had an informal and unofficial exchange of views with legal representatives of the International Joint Commission, the United States Department of State, the United States Coast Guard, and certain Canadian interests. The information developed by the Legal Committee is presented in this appendix to the WNB's report to Congress.

Two memoranda are attached to and made part of this appendix as exhibits. A memorandum by the Power Authority of the State of New York (hereafter Power Authority or PASNY) entitled Winter Navigation on the Great Lakes and St. Lawrence River addresses legal problems raised by the Demonstration Program particularly with reference to ice booms in the St. Lawrence River. A memorandum entitled Legal Considerations Relative to the Winter Navigation Program in the St. Lawrence River prepared by the Saint Lawrence Seaway Development Corporation (SLSDC) also addresses the legal considerations of the Demonstration Program and includes a discussion of the historical rights of navigation in the waters of the United States.

## III. Existing Power and Navigation Projects

In 1909, the Treaty Between the United States and Great Britain Relating to Boundary Waters and Questions Arising Between the United States and Canada was executed.[4/] Through this Treaty the United States and Canada sought to establish a means for preventing disputes involving the boundary waters. To achieve this end, the Treaty established the International Joint Commission (IJC). Among other responsibilities, the IJC was granted jurisdiction to approve further uses, obstructions, and diversions of the boundary waters. The decisions of the IJC on such matters are based on criteria set forth in the Treaty, including provisions for protection and indemnity against injury of any interest on either side of the boundary.

After 1909, the United States and Canada undertook studies concerning the development of the St. Lawrence River for power generation and the improvement of navigation. In 1952, upon application by the United States and Canada, the IJC issued an Order of Approval for the construction of the St. Lawrence Power Project in the St. Lawrence River and regulation of the level and flows of Lake Ontario and the River.[5/] By an exchange of notes in 1953, the Governments of the United States and Canada established the St. Lawrence River Joint Board of Engineers to approve and implement plans for the construction of the power project in accordance with the IJC Order.[6/] On July 15, 1953, the Federal Power Commission

4/ 36 Stat. (Part 2) 2448, 12 Bevans 319.

5/ *St. Lawrence Power*, IJC Docket No. 68 (1952).

6/ 5 U.S.T. 1784; T.I.A.S. 3053.

(FPC)[7] issued PASNY a license to undertake the project in accordance with the Federal Power Act.[8] The power project was then constructed by PASNY and Ontario Hydro.

Meanwhile, the development of the St. Lawrence River for navigation was also undertaken. By means of independent legislation in both the United States and Canada and exchanges of diplomatic notes between the countries (dated June 30, 1952, and August 17, 1954) the United States and Canada agreed to the construction of the St. Lawrence Seaway. The United States created and authorized the SLSDC in 1954 to participate on behalf of the Government of the United States in the construction of the Seaway.[9] Major facilities were finished in 1958, and the Seaway was opened to deep draft navigation in early 1959.

During construction of the power and navigation projects the power entities excavated nearly 63 million cubic yards of material in enlarging channels to provide to the extent practicable an adequate cross section in the river so that a stable ice cover would form in winter and to provide the desired navigation channels. Ice booms were not installed for the power project's first winter of operation in 1958-59.

During the first winter of operation adverse weather conditions resulted in the formation of an ice jam upstream of the powerhouse. Fortunately, low water levels prevented any flooding problems on Lake

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7/ Under the Department of Energy Organization Act of 1977, P.L. 95-91, 91 Stat. 565g, the FPC was abolished and many of its functions, including those under section 10(a) of the Federal Power Act discussed herein, were transferred to the newly created Federal Energy Regulatory Commission.

8/ 12 F.P.C. 172 (1953)

9/ 33 U.S.C. §981 *et seq*.

Ontario. However, this ice jam did cause a reduction of flow, thereby decreasing power generation at the St. Lawrence and Beauharnois plants.

Discussions with Hydro Quebec, model studies at Ontario Hydro's hydraulic laboratory, and prototype velocity surveys led the power entities to conclude that floating ice booms offered a means by which an ice cover can be formed, thereby eliminating massive ice movement. Ice booms are large floating timbers fastened together with heavy steel cables and anchored to the river bottom. Five ice booms were installed prior to the 1959-60 winter season pursuant to the authorization of the St. Lawrence River Joint Board of Engineers issued on September 1, 1959. PASNY also applied for a permit under section 10 of the Rivers and Harbors Act of 1899 which was issued by the U.S. Army Corps of Engineers on December 22, 1959, to PASNY for the ice booms located in United States waters of the St. Lawrence River. A sixth boom was installed for the winter of 1960-61 pursuant to the authorization of the St. Lawrence River Joint Board of Engineers issued on August 4, 1960, and was relocated for the winter of 1961-62. Approval of the FPC was not requested.

The basic arrangement of the booms has remained unchanged since the winter of 1961-62. Boom names and general locations are indicated in the following table:

| Boom Name | Location |
|---|---|
| A (Ogdensburg-Prescott) | U.S. and Canadian waters |
| B (Chimney Point) | U.S. waters only |
| C (Galop on Butternut Island Spur) | U.S. waters only |
| D (South Galop) | U.S. waters only |
| E (North Galop) | Canadian waters only |
| F (Main Galop) (relocated as G Boom) | U.S. and Canadian waters |

In general, the booms have minimized ice movement and have averted ice blockages such as those experienced during the winter of 1958-59. Since that time the winter outflows for the period December 15 through March 31 prescribed by the IJC plan of regulation for Lake Ontario have been released each year without difficulty and have been substantially greater than those released during the same period in 1958-59.

The present procedure for installing the booms is predicated upon the fact that only two of the six booms (A and G) cross the navigation channels and that navigation from upstream into the Prescott-Cardinal reach of the river may continue up to two weeks beyond the official closing of the St. Lawrence River Section of the Seaway. In late November, installation begins with the placement of four complete booms (B-E), shore sections of the Ogdensburg-Prescott Boom, and sections of the Main Galop Boom. Closure of the navigation gaps, nominally 2,000 feet, in the Ogdensburg-Prescott (A) and Main Galop Booms (G) begins when the water temperatures at the St. Lawrence Power Dam reach $33^{\circ}$ F. The closure of these two gaps has been completed as long as 16 days after the date announced for official closure of the St. Lawrence River section of the Seaway to commercial navigation in order to accommodate ships which had not cleared by the official date.

Recognizing that no formal international control over the booms had been exercised since the dissolution of the Joint Board of Engineers in 1963, the IJC determined on January 14, 1974, that henceforth the six ice booms should be considered as included in the works approved by the IJC Order of Approval of October 29, 1952

and subject to IJC jurisdiction to the same extent as though mentioned specifically in that Order. In addition, the IJC stated that the prior approvals granted by the Joint Board of Engineers would be considered IJC approvals and any amendment thereto would require further IJC approval.

Although the existing ice booms aid the formation of a stable ice cover, once installed and closed there is no through navigation in the International Rapids Section of the St. Lawrence River. Navigation resumes after the cross-channel ice booms are removed.

To develop a means for overcoming the impediment that the closing of the ice booms presents to navigation, the WNB has approved and funded tests of ice navigation booms which employ a gate or gap in the boom to allow for the transiting of vessels. Field tests on certain aspects of the ice navigation booms were conducted at Ogdensburg, New York, and at Copeland Cut in the St. Lawrence River by the Ice Control Work Group under the direction of the SLSDC. Although these tests were successful, they were too limited in scope to demonstrate total practicability. Hydraulic model tests are scheduled for the summer of 1978 with field tests, if justified, for the winter of 1978-1979.

The WNB has considered installation of structures in other locations. For example, during the winters of 1975-76 and 1976-77, an ice boom was installed and demonstrated in the St. Marys River for the purpose of controlling ice movement. Each winter the boom was inoperative for approximately 48 hours when anchor chains were dislodged due to ships being off course. Concern has been expressed by Canadian interests over

possible transboundary effects of such a boom in the St. Marys River. However, no adverse impacts are known to have occurred in Canada.

## IV. Legal Issues

The legal issues relevant to winter navigation involve responsibility and liability for damages which could result from the efforts of the WNB and interested federal agencies to extend the navigation season pursuant to Section 107 of the River and Harbor Act of 1970, as amended. The areas of potential impact which may be associated with an extension of the navigation season are: (a) impacts from flooding; (b) shoreline structural damage; (c) shoreline erosion; (d) adverse impacts on power generation; and (e) adverse environmental and social impacts. The possible impact on all phases of the human environment will be examined in the environmental impact statement which the WNB is preparing in conjunction with the entire program. Detailed studies under the extended season authorization have been undertaken to determine the specific causes of such environmental impacts, the recommended plan for remedial measures, and the federal and local responsibility for cost sharing.

Some types of potential damage are incidental to navigation such as damage to locks, harbor facilities, and vessels. While the possibility of such types of damage exist at all times, they may occur with greater frequency and potentially greater severity during the periods when ice is present. Other types of damage, primarily ice-related, include ice scouring of the shoreline, damage to shoreline structures such as piers and boathouses, ice clogging of water intakes and sewage outfalls,

and reduction of flows at powerhouses due to ice jams. Ice-related damages may occur naturally whenever the integrity of the ice cover is disrupted by severe weather or mild temperatures, especially if they occur in an adverse sequence. Under an extended navigation season, it may be difficult in some circumstances to determine whether damages would be due to extended season operation and activities or would have occurred naturally without season extension.

PASNY has suggested that the transiting of a stable ice cover by vessels would disrupt the ice cover which could result in ice jamming downstream. It has also been suggested that alteration or interference with the present ice control system approved by the IJC and operated by PASNY and Ontario-Hydro on the St. Lawrence River could cause an ice jam. The elevation of the water level upstream of an ice jam could cause flood damage to riparian property owners within the affected area. Additionally, the change in the water level and flow resulting from an ice jam could have an adverse impact on power generation as well as on domestic and sanitary uses and downstream navigation.

Since the installation or modification of an ice boom or other structure for navigation in the St. Lawrence River, the St. Marys River, or elsewhere in boundary waters can have international legal implications, responsibility and jurisdiction over such structures, with respect to Canadian rights and interests, will be addressed. Legal implications of extending the navigation season will also be addressed under domestic law in terms of impacts on riparian, navigation and power interests.

The riparian rights doctrine, which is found in the common law of the states, provides the starting point for determining the rights and

liabilities of parties in the United States. The United States Constitution and several federal statutes also affect the rights and liabilities of parties in the United States. International aspects are governed by the Boundary Waters Treaty which superimposes its legal framework on domestic law.

## V. Discussion

This section examines the responsibility and liability for structures and activities associated with winter navigation in the context of the legal issues identified above.

### A. Liability for Riparian Damage

#### 1. Domestic Claims

##### a. Types of Claims

Claims may arise incident to winter navigation demonstration activities. Claims could also arise from ongoing agency activities in support of a permanent program. Except as otherwise noted, claims arising from either the demonstration program or a permanent program will be treated the same. The types of potential damage which may give rise to claims include damage to shoreline structures due to ice agitation, shoreline erosion due to ice scouring, and flooding due to ice jams. Impact on power generation is discussed in a later section.

##### b. Riparian Rights

A riparian landowner is a person who owns land which is abutted or traversed by a river, stream, or lake.[10/] Possible riparian

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10/ Although the word "riparian" strictly speaking refers only to land adjacent to rivers, it is commonly used to include land adjacent to lakes and seas.

damage from an extension of the navigation season includes damage to shoreline structures, shoreline erosion, and damage from flooding. There is no authority under United States law suggesting that liability for riparian damage resulting from winter navigation is to be treated any differently than liability for damage resulting from navigation in general.

In the United States, a riparian owner has certain legal rights which are incident to his ownership of riparian land. Some of the more important of these rights include the right to access to the water; the right to extract and use the water; the right to have the water flow in its natural course, mode, condition, and channel; and the right to use the stream for the generation of power. In general, a riparian owner has a cause of action when there is interference with his riparian rights. Although riparian rights are subject to reasonable regulation by the state and federal governments, a taking of certain riparian rights generally entitles the riparian owner to compensation.

Riparian rights are not absolute. The rights can be exercised and protected only to the extent that such exercise or protection does not interfere with any corresponding rights of other riparian owners.

c. Navigation Rights

Since rivers are considered natural public highways for the use and benefit of the people, the rights of riparian owners are also subject to the exercise of navigational uses. As against a vessel in the water, a riparian owner ordinarily has no cause of action for injury to his land incident to the ordinary, careful navigation of the vessel on the water. Private property owners on navigable waters assume

the risk of such damage as an incident to their ownership of land abutting on navigable waters. Accordingly, the shore and structures adjacent to such waters are held subject to the rights of navigation, and a riparian owner cannot recover for wash, erosion, or other shoreline damage caused by a passing vessel which is exercising ordinary care. There is also authority suggesting that there would be no recovery for damage to a shoreline structure caused by ice agitated by a passing vessel. 11/

However, the rights of navigation are not exclusive either. A riparian owner can recover for damages sustained from a vessel if he can show willful damage or negligent operation of the vessel. One engaged in the navigation of a vessel is required to use reasonable care for the protection of all interests which could foreseeably be injured by the operation of the vessel. Thus, a riparian owner can recover if there was a breach of the duty of care in the operation of the vessel.

d. Federal Navigation Servitude

Riparian rights on navigable waters are also subject to the power of the federal government to regulate navigation under the commerce clause of the Constitution. 12/ In all navigable waters of the United States, the federal government has a dominant servitude which may be exercised in favor of navigation. To improve or promote navigation,

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11/ R&H Development Co. v. Diesel Tanker J.A. Martin, Inc. 203 A.2d 766 (1964). Although liability was found in this case, the court indicated that in the absence of negligence there would be no liability.

12/ United States v. Appalachian Electric Power Co., 311 U.S. 377, 61 S.Ct. 772 (1940).

Congress may exercise its dominant servitude in a way which alters, impairs, or takes away certain riparian rights. When Congress exercises its powers with respect to the dominant servitude, there is no legal taking and the riparian owner is not entitled to any compensation for such interference with his rights.[13/]

The dominant servitude of the United States extends up to the high water mark. For damages to fast land, i.e., above the high water, the United States may, in some instances, be liable to the owner of the land.[14/]

e. Sovereign Immunity

As a general principle, the United States enjoys sovereign immunity, i.e., the sovereign cannot be sued in its own courts without its consent. Several exceptions to this principle allow recovery against the United States under certain circumstances. These exceptions are reviewed below.

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13/ Gibson v. United States 166 U.S. 269, 17 S. Ct. 578 (1897).

14/ United States v. Kansas City Ins. Co. 339 U.S. 799, 70 S. Ct. 885 (1950).

#### (i) A Constitutional Taking

The Tucker Act waives the sovereign immunity of the United States with respect to claims either founded upon the Constitution, federal laws, federal regulations, or contracts, or for other cases not sounding in tort.[15/] Claims not exceeding $10,000 may be brought thereunder in United States district courts. Claims of any amount may be brought in the Court of Claims.

Under the Tucker Act the United States must compensate a riparian landowner if the damage to his land constitutes a "taking of property" within the meaning of the Fifth Amendment of the Constitution of the United States. To be a taking of property, the damage must be of a substantially permanent nature. For example, a flooding which permanently inundates fast land would be a taking and thus compensable. Likewise, a flooding which is inevitably recurring would also constitute a taking of at least an easement. On the other hand, a single flooding which later recedes or a flooding which only occurs under unusual and unpredictable circumstances does not constitute a taking and the federal government would not be liable for loss of land.

There are no known reported cases dealing with federal responsibility for erosion or shoreline structural damage caused by ice scouring or ice agitation related to navigation. When a federal project causes loss of riparian land above the high water mark, there is a compensable taking

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15/ 28 U.S.C. §1346.

if there is an actual physical invasion of the land by water or ice.[16/]
However, where there is no actual physical invasion of riparian land above the high water mark, loss of riparian land due to erosion has been held not to be a taking and thus not compensable.[17/]

In applying the law of these two cases to ice-induced erosion, there would be a basis for denying recovery for damage caused by erosion where such damages were not accompanied by a rise in the natural level of the water. However, there would be authority for recovery for loss of land due to erosion where there was a raising of the natural water level, e.g., by ice jams which result in an actual physical invasion of fast land by water or ice.

(ii) Liability under the Federal Tort Claims Act

Aside from liability based on a constitutional taking, the federal government could also be liable for riparian damage above the high water mark resulting from the government's negligence. Liability of this nature is predicated on the Federal Tort Claims Act.[18/]

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16/ See Dickinson v. United States 311 U.S. 745, 67 S. Ct. 1382 (1947).

17/ Pitman v. United States 457 F. 2d 975, 198 Ct. Cl. 82 (1972).

18/ 28 U.S.C.A. 2674.

The intent of this act is to waive sovereign immunity and make the United States liable for tort claims in the same manner and to the same extent as a private individual. Under this Act, a riparian landowner could recover for damages or loss of his property resulting from the government's negligence related to installation, operation, or maintenance of navigational works.[19]

There are several exceptions to the Federal Tort Claims Act which bar its application. The federal government is not liable under the Act for

> "Any claim ... based upon the exercise or performance or the failure to exercise or perform a discretionary function or duty on the part of a federal agency or an employee of the Government, whether or not the discretion involved be abused." 20/

The scope of the discretionary function exception is not easy to determine. A summary of this exception appears in volume 24 of the Federal Bar Journal (No. 2, Spring 1964):

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19/ Everitt v. United States 204 F.Suppl. 20 (1962).

20/ 28 U.S.C.A. 2680(a).

> "(1) When the claim arises out of the Government's decision to undertake a work project or a governmental program (such as the decision to change the course of a river), the discretionary function will apply. (2) When the claim arises out of the execution of the public works project or governmental program: (a) if the plan or design itself dictates the specifications, schedules, or details of the operation (such as where the plan dictates negligently designed dikes or revetments, or the plan calls for blasting...) which, when carefully adhered to, gives rise to the claim, the discretionary function exclusion is applicable; but (b) if there is a wrongful deviation from, or negligence in carrying out, the design, specification, schedules or other details of operation set forth in the overall plan, the discretionary function exception is not applicable; (c) if the overall plan is only general in terms and silent as to the details, discretionary function exception applies to a negligently conceived mode of execution (it is here that many decisions inject the planning vs. operational level test for applying the exception, ruling it inapplicable at the operational level. And (3) when the claim arises out of negligence in connection with operation and maintenance of public works or programs (such as where there is a negligent failure to light up navigation locks at night), the discretionary function is not applicable."

It can generally be stated that damages which are a result of a carefully planned and authorized study for the extended navigation season and which are envisioned by the plan and approved by higher authority would be considered discretionary functions and recovery would be barred. However, damages which result from the negligent, careless, willful, or wanton conduct of day-to-day activities of a government employee in connection with the program would be compensable under the Federal Tort Claims Act.

(iii) No Liability for Flood Damage

A broad immunity exists exempting the federal government from liability for flood damages.[21/] However, this immunity has been narrowly construed in view of the Federal Tort Claims Act to apply only to flood control projects.[22/] The present authorization of the winter navigation demonstration program may not be broad enough to take advantage of this immunity.

(iv) Administrative Settlement Under the Federal Tort Claims Act

Claims brought under the Federal Tort Claims Act must first be presented to the agency whose employee was allegedly responsible for the damage.[23/] The head of each federal agency, or his designee, may settle claims brought against the United States based upon actions of that agency's employees.[24/] Settlements not in excess of $2,500 are paid out of the agency's appropriations.[25/] Settlements in excess of $2,500 but not more than $100,000 are obtained through the General Accounting Office.[26/] All settlements exceeding $25,000 must be approved by the Attorney General or his designee.[27/] Settlements in excess of $100,000 will be forwarded to the Department of the Treasury which in turn submits them to the Office of Management and Budget for inclusion in a deficiency appropriation bill.[28/]

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21/ 33 U.S.C. § 702c
22/ Graci v. United States 456 F. 2d 20 (1971).
23/ 28 U.S.C. §2675(a).
24/ 28 U.S.C. §2672.
25/ Id.
26/ 28 C.F.R. 14.10.
27/ 28 U.S.C.A. 2672.
28/ 28 C.F.R. 14.10.

Claims arising from Corps of Engineers activities are to be presented to the unit involved or to the nearest Army post, camp, station, or other military establishment convenient to the claimant. 29/ District and Division Engineers have authority to pay meritorious claims for $5,000 or less. 30/ Claims greater than $5,000 must be referred to the U.S. Army Claims Service. 31/ For claims in excess of $25,000, consultation with the Department of Justice is also required. 32/

Claims arising out of the civil works activities of the Corps of Engineers are normally paid out of funds controlled by the Chief of Engineers. Claims in excess of $5,000 are forwarded by the District or Division Engineers through Engineer channels to the U.S. Army Claims Service. 33/

(v) The Military Claims Act

The Military Claims Act provides another authority for settling claims against the United States. 34/ A claim may not be considered under this Act if the Federal Tort Claims Act is applicable to the claim. 35/ A claim based on a negligent act may be settled under

29/ AR27-20 Ch. 2-10 d. (13).
30/ AR27-20 Ch. 4-15 b (1)(d).
31/ AR27-20 Ch. 2-11 c.
32/ 28 U.S.C.A. 2672.
33/ AR27-20 Ch. 2-21 f.
34/ 10 U.S.C. §2733.
35/ 10 U.S.C. §2733 (b)(2).

the Military Claims Act only if the Federal Tort Claims Act has been judicially determined not to be applicable to such type of claim.36/

Under the Military Claims Act, the Secretaries of the various military departments may establish procedures for the settlement of claims against the United States for damages or loss of property caused by non-combat activities of personnel of the various military departments. Claims not exceeding $25,000 may be paid under this authority.37/ District and Division Engineers of the Corps of Engineers have authority to approve and pay claims not in excess of $5,000.38/ Army claims in excess of $5,000 are forwarded to the U.S. Army Claims Service which has authority to settle claims not exceeding $25,000.39/ For meritorious claims in excess of $25,000, the Secretary of the military department may pay $25,000 to the claimant and report the excess to Congress for its consideration.40/

Claims may not be paid under this Act based upon the performance of a discretionary function.41/ This exception may be considered similar, if not identical, to the discretionary function exception to the Federal Tort Claims Act.

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36/ AR 27-20 Ch. 3-4(d).
37/ 10 U.S.C. § 2733.
38/ AR27-20 Ch. 3-14 b. (1) (g).
39/ AR27-20 Ch. 3-16 a., AR27-20 Ch. 2-11 b.
40/ 10 U.S.C. §2733(d).
41/ AR27-20 Ch. 3-5 b.

Army regulation provides guidance for choosing the applicable law for establishing the substantive elements of the claim. In the United States, the law of the place where the act or omission occurred governs. 42/

(vi) Liability in Admiralty

Under certain circumstances, the federal government could be liable for claims brought under the Suits in Admiralty Act 43/ or the Public Vessels Act. 44/ These two acts waive the government's sovereign immunity by allowing suits in admiralty against the United States for damages caused by government-owned vessels or cargo. To the extent that these statutes are applicable, the Federal Tort Claims Act does not apply. 45/

Application of the Suits in Admiralty Act or the Public Vessels Act depends upon government ownership of the vessel or cargo which causes the damage. 46/ Admiralty jurisdiction applies under these acts regardless of whether the damage is consummated on water or on land. 47/ Suits for damages caused by government-owned vessels engaged in season extension activities, such as ice-breaking, would be brought under the appropriate one of these acts.

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42/ AR27-20 Ch. 3-11 a.
43/ 46 U.S.C. §741 *et seq*.
44/ 46 U.S.C. §781 *et seq*.
45/ 28 U.S.C. §2680(d), 46 U.S.C.A. 740.
46/ 46 U.S.C. §S742, 781.
47/ 46 U.S.C. §740.

(vii) Administrative Settlement of Admiralty Suits

A claim for damages caused by a government-owned vessel must first be presented to the agency owning the vessel prior to initiation of suit against the United States. 48/ For claims involving vessels owned by the Army, the Secretary of the Army can settle and pay suits for damages up to $500,000. 49/ The Secretary may settle suits for more than $500,000, but these he must certify to Congress. 50/ A settlement for less than $10,000 can be made by the U.S. Army Claims Service. 51/

(viii) The Meritorious Claims Act

Claims against the United States which cannot otherwise be lawfully adjusted may be considered by the General Accounting Office, but relief under this authority is discretionary. 52/

2. Foreign Claims

a. A Constitutional Taking

Aliens holding property in the United States may recover for a government taking. 53/ United States citizens may recover for property taken by the United States in a foreign country. 54/ There is even an authority holding that aliens may recover for property taken by the United States in a foreign country. 55/

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48/ 46 U.S.C. § 740.
49/ 10 U.S.C. § 4802.
50/ Id.
51/ AR27-20 Ch.8-9.
52/ 31 U.S.C. §§71, 236.
53/ Russian Volunteer Fleet Co. v. United States 282 U.S. 481, 51 S. Ct. 229 (1931).
54/ Wiggins v. United States 3 Ct. Cl. 412 (1867); Seery v. United States 127 F. Supp. 601, 130 Ct. Cl. 481 (1955).
55/ Turney v. United States 126 Ct. Cl. 202, 115 F. Supp. 457 (1953); Fleming v. United States 352 F. 2d 533 173 Ct. Cl. 426 (1965); Porter v. United States 496 F. 2d 583, 204 Ct. Cl. 355 (1974).

As mentioned above, liability under the Tucker Act for a Fifth Amendment taking extends only to those takings which are substantially permanent in nature. Because of this limitation, the Tucker Act recovery for a Fifth Amendment taking may not be considered a satisfactory solution to handling possible Canadian claims arising from season extension activities.

b. Federal Tort Claims Act Application to Foreign Claims

An exception to the liability created by the Federal Tort Claims Act is provided to any claim arising in a foreign country.[56] This exception may bar claims arising from season extension activities in the boundary waters.

The Federal Tort Claims Act does not create any new causes of action. Rather, the Act subjects the federal government to liability as a private individual under state-created causes of action. In every Federal Tort Claims Act case, there is an underlying claim based on state law.

Sometimes, different elements of a tort can occur in different states. When this happens, a court employs "choice-of-law" rules to resolve which state's law is applicable to the case. These choice-of-law rules vary among the states. Most states apply the rule that the law of the state where the injury took place governs all the elements of a tort. However, recent trends in several states indicate a change toward using the law where the defendant's action took place. Other rules also exist in some states.

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56/ 28 U.S.C. §2680(k).

When a choice-of-law issue arises in a case brought under the Federal Tort Claims Act, the court must first turn to the whole law of the state where the government's act or omission took place.57/ "Whole law" of a state means all of that state's law including the state's choice-of-law rules. For example, where the federal government's action occurs in one state and the injury is sustained in a second state, the court applies the choice-of-law rules of the first state. If the choice-of-law rules of the first state refer to the law where the injury occurred, then the court applies the substantive law of the second state.

The Federal Tort Claims Act was held to be applicable in a case in which the Federal government was sued for injuries sustained outside the United States caused by acts occurring within the United States.58/ In another case a claim was denied as arising in a foreign country where the government's action occurred in a foreign country, but the injury was suffered in the United States.59/ Based on these precedents, it is conceivable that a government action on the United States side of the boundary resulting in damages in Canada would not be considered a "case arising in a foreign country." Consequently, under such an interpretation Canadians could bring a suit against the United States in our courts under the Federal Tort Claims Act.

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57/ Richards v. United States 369 U.S. 1, 82 S.Ct. 585 (1962).
58/ In Re Paris Air Crash 399 F.Supp. 732 (1975).
59/ Manemann v. United States 381 F.2d 704 (1967).

On the other hand, under the above mentioned cases, a government's negligent act occurring on the Canadian side of the boundary waters would be a case arising in a foreign country thereby barring recovery under the Federal Tort Claims Act even if the damage occurred solely on the United States side.

Although the above interpretation is consistent with the reasoning of the cases interpreting the Federal Tort Claims Act, it would be highly speculative to predict that a United States court would arrive at such a result. Because of the uncertainty associated with the application of the Federal Torts Claims Act to claims arising from activities in boundary waters, the Act cannot presently be considered a satisfactory vehicle for handling possible claims.

More difficult legal questions could arise if choice-of-law issues are involved. For example, if the state in which a government action occurs has a choice-of-law rule which refers to the place where the injury occurs, damage to Canadian land could require reference to Canadian law. In this situation, there is no satisfactory legal precedent as to whether the Federal Tort Claims Act would be applicable.

c. Claims Under the Foreign Claims Act

The Secretaries of the various military departments have authority to appoint claims commissions to settle and pay claims brought by foreign countries or individuals for damage or loss

of property located in foreign countries.[60] These commissions have authority to pay claims not exceeding $25,000.[61] For meritorious claims in excess of $25,000, the Secretary may pay the claimant $25,000 and certify the excess to Congress. [62]

Claims arising in Canada resulting from the activities of any department of the armed services are handled by the Department of the Air Force.[63]

At the present time, any Canadian claims arising from season extension activities of the Corps of Engineers in boundary waters cannot be excluded from consideration under the Foreign Claims Act. However, the Foreign Claims Act cannot be considered a satisfactory vehicle for handling such claims for the following reasons: (1) settlement authority is limited to $25,000 per claim; (2) there is no recourse to the courts after an unfavorable administrative decision; (3) there are no definite standards which establish liability.

### d. The Military Claims Act

Settlement of claims under the Military Claims Act is not limited only to claims arising in the United States but also to

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60/ 10 U.S.C. § 2734(a).
61/ 10 U.S.C. § 2734(d).
62/ Id.
63/ Department of Defense Directive 5515.8, AR27-20 Ch. 10-22 b. (3).

claims arising in foreign countries as well.[64/] As mentioned with respect to domestic claims, settlement authority under the Military Claims Act is limited to $25,000. Also, the discretionary function exception bars recovery under the Act. [65/]

With regard to claims arising in foreign countries, Army regulation provides that liability normally will be established in accordance with general principles of American law. [66/] However, principles of absolute liability will not be applied against the United States, and the law of the place where the act or omission occurred will govern issues of contributory or comparative negligence.[67/] Amount of damages will be determined in accordance with general principles of American law. [68/]

e. Foreign Claims Payable by the Secretary of State

The Secretary of State also has authority to settle claims brought by a foreign government if the claims are not cognizable under any other statute or agreement.[69/] Claims payable under this authority may not exceed $15,000.

Like the Foreign Claims Act, settlement of claims under this authority is unsatisfactory for the following reasons: (1) settlement authority is limited to $15,000; (2) there is no recourse to the courts after an unfavorable administrative decision; and (3) there are no definite standards establishing liability.

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64/ 10 U.S.C.A. 2733.
65/ AR27-20 Ch. 3-5 b.
66/ AR27-20 Ch. 3-11 b.
67/ Id.
68/ AR27-20 Ch. 3-11 d.
69/ 22 U.S.C. § 2669(b).

### f. The Meritorious Claims Act

As mentioned above, the General Accounting Office has authority to pay claims against the United States which cannot otherwise be lawfully adjusted. This act cannot be considered as providing satisfactory procedure for handling Canadian claims because relief under the act is entirely discretionary.

## B. Liability for Impacts on Navigation and Transportation

Permanent extension of the navigation season would have impacts on navigation interests. The Demonstration Program identifies and addresses these problems. The legal implications of these impacts are believed to relate primarily to private navigation interests and not the federal government. Therefore, the legal implications regarding federal interests are not addressed in this appendix.

Permanent extension of the navigation season would also have adverse impacts on some present forms of transportation. Where ferrys provide transportation for people living on islands, for example in the St. Marys River, commercial traffic during the ice period can disrupt service. Normally, such ferrys operate in open water below natural ice bridges. Navigation in the St. Marys River during the winter season contributes to frequent breaking up of these natural ice bridges, which permits ice to fill in the ferry tracks and thus disrupt services.

Winter navigation in the St. Marys River resulting in disruption of the solid ice cover is also blamed for hindering travel by foot, sled, or snowmobile over the solid ice cover in some places. To the extent that such activities are subject to the Federal Government's dominant servitude in favor of navigation, there would appear to be no legal liability for such disruptions.

### C. Liability and Existing Responsibility for Impacts on the Power Entities

In order to extend the navigation season in the International Rapids Section of the St. Lawrence River, a means must be provided to transit the ice booms operated by PASNY and Ontario-Hydro. The installation of a navigable gate or gap in the ice booms is currently under consideration for this purpose. A test of a navigable ice boom in the river near Ogden Island has been proposed.

As noted earlier, PASNY is concerned with the legal impacts associated with modification of the ice booms and the transiting of the ice booms by vessels in the St. Lawrence River. A summary of PASNY's position and the response of the navigation interests are set forth below.

#### 1. The Concerns and Position of Power Authority

PASNY's concerns are twofold: winter navigation extension activities could cause ice jams which could in turn (1) have an adverse

impact on hydroelectric power generation and (2) cause flooding upstream on the river and on Lake Ontario for which it might be held liable. In particular, ice jams could reduce the flow of water in the St. Lawrence River and thus decrease the head and volume of water available for power generation at the St. Lawrence Power Dam and downstream at Hydro Quebec's Beauharnois Station. Flow reduction for an appreciable length of time in the river could also cause the level of the river upstream of the jam and the level of Lake Ontario to rise to levels higher than would have existed had regulation plan flows been released. This has been evidenced when an early onset of ice conditions combined with continuing navigation activities delayed the closing of the ice booms and the development of a satisfactory stable ice cover at an appropriate time.

PASNY is not alone in expressing concern. The Chairman of the FPC commented on the Corps of Engineers proposed report and on the reports of the Board of Engineers for Rivers and Harbors and of the District and Division Engineers on the Great Lakes-St. Lawrence Seaway, Navigation Season Extension, as follows:

> "A word of caution must be given with respect to future efforts to extend the navigation season on the St. Lawrence River. The efficient winter operation of the combined United States-Canadian hydroelectric plant on the St. Lawrence River is dependent upon the early formation of a stable ice cover to permit flows under the ice without excessive head losses which can result from a cover thickened as a result of broken ice. Operation of

> the hydroelectric plants at Niagara Falls and the prevention of ice jams and resultant riparian damage along the shores of the Niagara River are likewise dependent on control of ice at the head of the Niagara River. The matter of liability for damages if the ice booms are opened for navigation must be resolved before extension of the season on the St. Lawrence is considered." 70/

In light of these concerns it is PASNY's view that the 1952 IJC Order of Approval, the FPC license for the St. Lawrence Power Project, and the subsequent IJC approval of the ice booms establish the legal authority for the continued operation of the entire project, including the ice booms, as presently constructed and operated until such time as the IJC and the FPC take action to modify either the project works or the plan of operation in accordance with applicable legal requirements. Thus, PASNY maintains that:

(1) PASNY's liability for damages, its duties with respect to navigation and other beneficial public uses, and its right to use the waters of the St. Lawrence River for power production are set forth in the 1909 Treaty, the IJC Orders, the Federal Power Act and PASNY's FPC license;

(2) PASNY might be liable for damages due to injury to third party rights attributable to its acquiescence in any ice boom modifications;

(3) Such acquiescence could injure PASNY's right to use the water for power purposes; and

(4) Any modification of the ice booms must be approved by the IJC and the FPC, taking into account all the safeguards provided in the 1909 Treaty and IJC Orders, and the Federal Power Act and PASNY's FPC license.

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70/ Letter from Richard L. Dunham to J. W. Morris (January 27, 1977).

Since PASNY's position is set out in detail in the attached memorandum of September 10, 1975, to the Legal Committee, only a brief summary is presented below.

As noted earlier, the IJC determined in January 1974 that the six ice booms should be considered as included in the works approved by its 1952 Order of Approval. This formal assumption of jurisdiction was concurred in by both Governments, and the power entities were notified of this formal determination in October 1974. In pertinent part the notice states that the approvals given by the Joint Board of Engineers to the power entities are to be considered IJC approvals and that any amendments thereto would require further IJC approval. 71/ Since the approvals of the Joint Board were issued subject to the condition that any significant modifications in the design or location of the booms would require further approval by the Joint Board, 72/ PASNY believes that no significant modification of the six ice booms in order to facilitate any winter navigation program or other purpose is permissible without IJC approval thereof.

PASNY also believes that the Federal Power Act independently requires PASNY to obtain prior FPC approval for any substantial alteration to the ice booms or other project works in connection with the winter navigation demonstration program. Section 10(b) of the Federal Power Act

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71/ Letter from International Joint Commission to Power Authority of the State of New York, October 11, 1974.

72/ Letters from St. Lawrence River Joint Board of Engineers to Hydroelectric Power Commission of Ontario, September 1, 1959, and August 4, 1960.

provides that no substantial alteration or addition shall be made to any dam or other project works without the prior approval of the FPC.73/ This requirement was specifically incorporated into PASNY's FPC license for the project.74/ Under the Federal Power Act project works are the physical structures of the project, such as the forebay reservoir or powerhouse. The project is the complete unit of improvement which includes all miscellaneous structures the use and occupancy of which are necessary or appropriate in the operation of the unit. 75/

In issuing the license, the FPC expressly found that the project would include principal project works such as Lake St. Lawrence and all other structures, fixtures, equipment, or facilities "including such portable property as may be used or useful in connection with the project." 76/ Consequently, it is PASNY's view that the six ice booms, as portable property useful in connection with operation of the project, and Lake St. Lawrence, as the forebay reservoir, are "project works" within the meaning of the Federal Power Act and its license, and a substantial alteration of the booms or the level of the reservoir is prohibited without prior FPC approval pursuant to section 10(b).

While PASNY did obtain a Department of the Army permit under Section 10 of the River and Harbor Act of 1899, such permit was not required nor was it applicable to the project works since the licensing authority vested in the FPC under the Federal Power Act preempts the permitting authority delegated to the Corps of Engineers under the River and Harbor Act.77/

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73/ 16 U.S.C. §803(b).
74/ 12 F.P.C. at 186.
75/ 16 U.S.C. §§796(11), (12).
76/ 12 F.P.C. at 180-181.
77/ Scenic Hudson Preservation Conference v. Callaway, 370 F.Supp. 162 (S.D. N.Y. 1973), aff'd 499 F.2d 127 (2nd Cir. 1974).

PASNY's concerns regarding its potential liability are also grounded in the IJC order, its FPC license and the Federal Power Act. Condition (a) of the IJC order provides that all interests on either side of the International Boundary which are injured by the construction, maintenance and operation of the works must be given suitable and adequate protection and indemnity in accordance with the laws of Canada and the United States. The relevant laws of the United States are, of course, the provisions of the Federal Power Act. With respect to such protection and indemnity section 10(c) states:

> "Each licensee hereunder shall be liable for all damages occasioned to the property of others by the construction, maintenance, or operation of the project works or of the works appurtenant or accessory thereto, constructed under the license, and in no event shall the United States be liable therefor." 78/

In the context of the other provisions of the Federal Power Act, 79/ section 10(c) has been construed by the courts to require a licensee such as PASNY to pay just compensation for destruction of, or interference with, vested water rights and other property interests held under State law. 80/ Hence, the matter of PASNY's potential liability for injuries to third party rights attributable to PASNY's acquiescence in any ice boom modifications to facilitate winter navigation must be resolved satisfactorily prior to commencement of such activities.

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78/ 16 U.S.C. §803(c).

79/ In particular, see section 27, 16 U.S.C. §821.

80/ FPC v. Niagara Mohawk Power Corp. 347 U.S. 239 (1954); Henry Ford & Son, Inc. v. Little Falls Fibre Co. 280 U.S. 269 (1930); Portland General Electric Co. v. FPC 328 F.2d 165 (9th Cir. 1964); U.S. v. Central Stockholders Corp. 52 F.2d 323 (9th Cir. 1931).

Adequate compensation for any injury to PASNY's rights under its FPC license must also be provided. It must be emphasized that a FPC license to construct a power project authorizes the licensee to "appropriate water resources from the public domain."81/ In addition, Section 28 of the Federal Power Act provides that no amendment thereto shall affect any license theretofore issued under the Federal Power Act, or the rights of any licensee thereunder.82/ Under Section 6 of the Federal Power Act the terms of any license may not be altered by the FPC without the licensee's consent. These provisions are incorporated in the Federal Power Act to give the necessary security to the capital invested in non-Federal hydro projects.83/ Of course, PASNY has incurred a substantial debt and made a corresponding investment in the project on the strength of the foregoing statutory safeguards. Therefore, PASNY cannot consent to any diminution of its rights as a licensee without obtaining adequate provision for compensation.

PASNY recognizes that the Federal Power Act and its FPC license subject it to reasonable regulations in the interest of promoting and protecting navigation and other beneficial public uses of the waterway.84/ For example, Article 10 of PASNY's license states that whenever the United States desires to construct navigation facilities in connection with the project, PASNY shall convey to the United States such lands and rights of passage through its dam or other structures and permit such

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81/ Udall v. FPC 387 U.S. 428, 450 (1967); Municipal Electric Assn of Mass. v. FPC 414 F.2d 1206, 1207 (D.C. Cir. 1969).

82/ See 16 U.S.C. §822; Scenic Hudson Preservation Conf. v. Callaway 370 F. Supp. 162 (1973), Aff'd 499 F.2d 127 (2d Cir. 1974).

83/ Iowa Hydro-Electric v. FPC 328 U.S. 152, 179-181, 66 S.Ct. 906, 918-920, n. 23 and 24 (1946).

84/ See 16 U.S.C. §811; 12 FPC at 188-189.

control of pools as may be required to complete such navigation facilities. However, this obligation must be interpreted consistent with the remaining articles and provisions of PASNY's license and the Federal Power Act. Thus, the control of pools is also subject to Article 19 of the license which requires compliance with the IJC Order of Approval and consequently the IJC plan of regulation governing flows and levels. Moreover, no alterations to the project under Article 10 can be effected unless the FPC is able to find that the project as altered would remain best adapted to a comprehensive plan for development for the waterway as required by section 10(a) of the Federal Power Act.

PASNY also recognizes that uses for navigation purposes generally take precedence over uses for power purposes under Article VIII of the Treaty. Nevertheless, it is a matter of record that the St. Lawrence Power Project was designed, approved and constructed on the assumption that a stable ice cover would be formed each winter.[85/] In view of its extensive experience PASNY remains unconvinced that a stable ice cover can be established and maintained while navigation continues beyond the critical ice-forming period. Under these circumstances it should be obvious that the IJC Order of Approval has established a reasonable balance among the uses of the river which is consistent with the order of precedence in the Treaty and which presently excludes winter navigation.

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85/ See International St. Lawrence River Board of Control, Operations Advisory Group, Report on the Timing of Power Entities' Ice Boom Installation and Removal 2 (1970); International Joint Commission Order of Approval at 3 (October 29, 1952); U.S. Army Corps of Engineers, Final Report, St. Lawrence River Project, Appendix A-2 at 34-35 (1942); Report of Joint Board of Engineers on St. Lawrence Waterway Project 248 (1926).

Moreover, the FPC has found that the project as constructed, operated and maintained is best adapted to a comprehensive plan of development for the waterway in accordance with section 10(a) of the Federal Power Act for all beneficial public uses, including navigation and power. Relying on the IJC approval and the FPC finding, which was required as a matter of law to be made before the FPC license could be issued, PASNY made a substantial investment to develop the project and thus carry out the balance struck by the IJC and FPC. An alteration of the established balance to permit an extension of the navigation season would be in accordance with domestic law only if the FPC is able to find that the project as altered would continue to meet the comprehensive plan test of section 10(a) of the Federal Power Act. PASNY believes that such alteration would have to be conditioned upon adequate compensation to PASNY for any injury to its substantial power interest and further conditioned to relieve it of potential liability in order to meet this requirement. Furthermore, such alteration would be in accordance with international law only if the IJC could condition its approval thereof upon provision of suitable and adequate protection and indemnity for PASNY's substantial power interest pursuant to Article VIII of the Treaty.

2. Position of Navigation

Navigation interests believe that sufficient authority already exists to conduct the season extension demonstration program activities in the St. Lawrence River. There is no rational basis nor legal precedent for differentiating between "navigation" and "winter navigation." It is the opinion of navigation interests that since the various statutes, licenses and permits under which PASNY has constructed and now operates its St. Lawrence River facilities all require that PASNY operate those facilities in the manner most conducive to the needs of navigation, it is incumbent upon PASNY to accommodate winter navigation. This is corroborated by the fact that the licenses and permits speak in terms of the future needs of the Government for navigation as well as those recognized at the time the project was undertaken.

The first relevant authority dealing with PASNY's responsibilities is its own enabling legislation.[86/] That statute begins with a declaration of policy which states that "those parts of the St. Lawrence and Niagara rivers within the boundaries of the state of New York are hereby declared to be natural resources of the state for the use and development of commerce and navigation in the interest of the people of the state and the United States." 87/ The declaration of policy also states that "a continuous and adequate supply of dependable electric power and energy is a matter of public concern to the people of the state." 88/ To effectuate this policy the Power Authority of the State of New York was created and given the authority to

86/ Power Authority Act of New York, L 1939, c 870, eff. June 15, 1939.
87/ Id.
88/ Id.

proceed, in cooperation with appropriate Canadian and U.S. Authorities, with the improvement and development of the St. Lawrence River for the aid and benefit of commerce and navigation and the development of hydro-electric power inherent therein. 89/

Specifically the New York statute directs PASNY to:

> "...cooperate with the appropriate agencies and officials of the United States government to the end that any hydroelectric project on the Niagara or St. Lawrence rivers undertaken under this title shall be consistent with and in aid of any plans of the United States for the improvement of commerce and navigation along such rivers and shall be so planned and constructed as to be adaptable to the plans of the United States thereof, so that the necessary channels, locks, canals and other navigational facilities may be constructed and installed by the United States, in, through, and as part of projects." 90/

The Power Authority Act also contains the state's consent to PASNY's exercise and use of any and all of the state's proprietary and sovereign rights and powers on the St. Lawrence River provided that "such consent... shall not permit the impairment or limit or prevent the future improvement of the navigability of the St. Lawrence River, consistent with the maintenance of such projects, but on the contrary the projects shall be such as will improve and benefit commerce and navigation therein." 91/

It is apparent from the foregoing that the legislature of the State of New York realized that the hydroelectric potential of the St. Lawrence could be developed in a manner which would preclude its future improvement for navigation and wanted to assure that that did not happen.

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89/ Id. at 1005.
90/ Id. at 1005 (1).
91/ Id. at 1008.

The New York statute also directs PASNY to apply to appropriate agencies of the United States Government, including the FPC, and the IJC for such licenses, permits or approvals as it feels may be necessary and to accept such licenses, permits and approvals upon such terms and conditions as PASNY deems appropriate, with the express proviso that this apparently discretionary authority is not to be construed as limiting the power of the Power Authority to accept licenses issued by the Federal Power Commission pursuant to the Federal Power Act, as amended, and the terms and conditions therein imposed pursuant to law. 92/

The conditons imposed on the St. Lawrence River project by such licenses, permits and approvals are reinforced by PASNY's enabling legislation. This means that PASNY's bondholders and its customers entered into their respective dealings with PASNY subject to all the conditions, provisos, and limitations contained in PASNY's licenses, permits, and approvals. To the extent these require PASNY to provide for and accommodate the future requirements of navigation, PASNY has available with respect to third parties the defense of constructive, if not actual, notice of prior conditions imposed by law should it be sued for breach of contract or for default of an obligation.

Turning now to the actual Federal power licensing process, the Federal Government, by virtue of its constitutional power to regulate interstate and foreign commerce, has paramount control of all the navigable waters of the United States.93/ Pursuant to this constitutional power, Congress passed the Federal Water Power Act in 1920.94/ By this Act Congress created the Federal

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92/ *Id.* at 1005
93/ U.S. v. Appalachian Electric Power Co. 311 U.S. 377, 61 S. Ct. 291 (1940)
94/ 16 U.S.C. § 791 *et seq.*

Power Commission which is authorized and empowered to issue licenses for the construction of project works across, along, or in navigable waters of the United States.

The Federal Power Act empowers the FPC to condition issuance of a license upon construction by the licensee of structures for navigation purposes consistent with a reasonable investment cost to the licensee.[95/] When such navigation structures are not part of the original construction, the FPC may also condition issuance of the license upon agreement by the licensee to convey lands, rights-of-way and rights of passage through its structures as needed for the completion of such navigation facilities.[96/]

As a FPC licensee, PASNY is required to adhere to the conditions of its license which was issued on July 15, 1953.[97/] Article 10 thereof provides:

> Whenever the United States shall desire to construct, complete, or improve navigation facilities in connection with the project, the licensee shall convey to the United States, free of cost, such of its land and its rights-of-way and such right of passage through its dam or other structures, and permit such control of pools as may be required to complete and maintain such navigation facilities. 98/

This condition in the PASNY license pertains to the improvement of navigation facilities as well as to their original construction. It remains an effective condition of PASNY's license and would appear to compel not only PASNY's cooperation with the efforts to extend the navigation season but its financial participation in such efforts as well.

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95/ 16 U.S.C. 804(a).
96/ 16 U.S.C. 804(b).
97/ 16 U.S.C. 799.
98/ 12 F.P.C. 188.

The next authority which establishes PASNY's responsibility to cooperate with efforts to extend the navigation season is the Boundary Waters Treaty of 1909. Inasmuch as the U.S.-Canada border follows the International Rapids Section of the St. Lawrence River, the development of that section for power required appropriate international approval as well as approval of the State of New York and the Federal government through the FPC.

The Boundary Waters Treaty of 1909 is the basic cornerstone of the legal framework governing the boundary waters between the United States and Canada. Its purpose is the prevention of disputes between the United States and Canada by appropriate regulation of the boundary waters. These boundary waters are defined in the Preliminary Article of the Treaty as "the waters from main shore to main shore of the lake and river connecting waterways, or portion thereof, along the international boundary..." 99/

Article III of the Treaty states the conditions for any use in the boundary waters which affect the natural level or flow on the other side.

> "It is agreed that, in addition to the uses, obstructions and diversions heretofore permitted or hereafter provided for by special agreement between the Parties hereto, no further or other uses or obstructions or diversions, whether temporary or permanent, of boundary waters on either side of the line, affecting the natural level or flow of boundary waters on the other side of the line shall be made except by authority of the United States or the Dominion of Canada within their respective jurisdictions and with the approval, as hereinafter provided, of a joint commission, to be known as the International Joint Commission." 100/

99/ 36 Stat. (Part 2) 2448, 12 Bevans 319.
100/ *Id.*

Article VIII of the Treaty provides the applicable rules or principles to be used by the IJC when it considers an application for approval of a use, diversion, or obstruction under Article III. Article VIII provides an order of precedence for giving preference to conflicting uses:

> "The following order of precedence shall be observed among the various uses enumerated hereinafter for these waters, and no use shall be permitted which tends materially to conflict with or restrain any other use which is given preference over it in this order of precedence:
> (1) Uses for domestic and sanitary purposes;
> (2) Uses for navigation, including the service of canals for the purposes of navigation;
> (3) Uses for power and for irrigation purposes." 101/

Pursuant to the Boundary Waters Treaty and in accordance with the requirements set forth in Article VIII, the IJC issued its Order of Approval for the power project in the International Section of the St. Lawrence River on October 29, 1952. Navigation interests believe that there is no indication that in issuing its Order, the IJC ignored Article VIII of the Treaty and attempted to balance conflicting uses of the St. Lawrence River. Rather, the IJC recognizes and preserves the superior rights of navigation. Particularly, provision (b) of the Order states:

> "The works shall be so planned, located, constructed, maintained and operated as not to conflict with or restrain uses of the waters of the St. Lawrence River for purposes given preference over uses of water for power purposes by the Treaty, namely, uses for domestic and sanitary purposes and uses for navigation, and shall be so planned, located, constructed, maintained and operated as to give effect to the provisions of this Order."

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101/ Id.

The above mentioned authorities apply to the power works as a whole. However, with respect to the ice booms in particular, there are additional authorities.

As early as 1926, the possibility of employing ice booms to create an ice cover on the St. Lawrence River was considered. 102/ Nevertheless, neither the IJC Order of Approval nor the FPC license contemplated the annual installation of ice booms as part of the power works.

In 1959, the power entities determined that ice booms would afford the best solution to the problem encountered during the winter of 1958-59 with respect to maintaining a stable ice cover in the St. Lawrence River. Upon application by the power entities, the Joint Board of Engineers 103/ gave its approval on September 1, 1959, to the installation of certain ice booms, subject to several provisions. Most significant of these provisions from the standpoint of navigation is that identified as paragraph 4:

> "The placement and removal of ice booms shall be timed so as not to interfere with the requirement of navigation and the St. Lawrence Seaway Authority, and the St. Lawrence Seaway Development Corporation shall be kept informed of all such operations."

PASNY also sought and obtained a permit from the Corps of Engineers for the placement of an obstruction in the navigable waters of the United States under the River and Harbor Act of 1899. 104/ This permit was granted to "place an ice boom during the non-navigation season at... locations in United States waters of the St. Lawrence River" subject to

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102/ Report of the Joint Board of Engineers, November 1926.
103/ Despite the similarity of names, this was a different Joint Board of Engineers from that which submitted the 1926 Report. This latter Joint Board was established by the two governments for the purpose of reviewing, coordinating, and approving the plans and specifications of the power works approved by the IJC in its Docket No. 68 and the construction program for those works.
104/ 33 U.S.C. § 403.

conditions. The condition preserving the rights of navigation is particularly noteworthy because the future requirements of the United States are specifically dealt with:

> "(f) That if future operations by the United States require an alteration in the position of the structure or work herein authorized, or if, in the opinion of the Secretary of the Army, it shall cause unreasonable obstruction to the free navigation of said water, the owner will be required upon due notice from the Secretary of the Army, to remove or alter the structural work or obstructions caused thereby without expense to the United States, so as to render navigation reasonably free, easy, and unobstructed; and if, upon the expiration or revocation of this permit, the structure, fill, excavation, or other modification of the watercourse hereby authorized shall not be completed, the owners shall, without expense to the United States, and to such extent and in such time and manner as the Secretary of the Army may require, remove all or any portion of the uncompleted structure or fill and restore to its former condition the navigable capacity of the watercourse. No claim shall be made against the United States on account of any such removal or alteration. 105/

On the basis of these authorities PASNY has, since 1959, closed the ice booms each winter and removed them each spring.

In 1964, the St. Lawrence River Joint Board of Engineers was formally dissolved. This jurisdictional void presented no problem until it became apparent that the season extension effort would require an alteration of the annual ice boom routine. On January 14, 1974, the IJC formally took notice of the ice booms and stated that the ice booms were to be considered works subject to the 1952 Order of Approval. The United States and Canada concurred in this determination. Also, in the letter of August 5, 1974, to the IJC in which the United States, speaking through the Department of State, concurred in the determination that the ice booms were project works subject to the 1952 Order of Approval, it is stated that the rights of navigation established by the Order are to be reserved.

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105/ Department of Army Permit dated December 22, 1959.

"The United States Government has carefully examined the implications of the Commission's request for the assumption of jurisdiction and is of the opinion that the Commission has the authority to exercise such jurisdiction. The United States Government wishes to note, however, that in the exercise of jurisdiction the commission is subject to the order of precedence established by the Boundary Waters Treaty of 1909 and that: (a) such jurisdiction is subject to the express reservations contained in the United States Application of the Commission of June 30, 1952, and in particular, Sections 12, 13, and 14 of that application, (b) the approval of assumption of jurisdiction over the international aspects of the subject ice booms does not abrogate or supersede the authority of the Secretary of the Army to prevent the obstruction of the navigable waters of the United States under 33 USC 403. The ice booms and their operation shall remain subject to the Department of the Army permits authorizing their placement. (c) Further, in accordance with your letter of January 28, the United States will regard the approvals of the International St. Lawrence Joint Board of Engineers on August 4, 1960, as an approval given by the Commission."

The authorities described above clearly express an intention to give navigation superior rights over power. Furthermore, several of the authorities express the intention to reserve the right to require modification of power works in the future in accordance with the developing needs of navigation. In view of these authorities, it would appear that modification of the ice booms presently installed by PASNY and Ontario-Hydro can be required to meet the needs of an extended navigation season in the St. Lawrence River.

3. <u>Concluding Comments of the Chairman of the Legal Committee</u>

In the preparation of this appendix, the Legal Committee has sought to bring to the attention of the Winter Navigation Board the concerns which the Board may in turn wish to present to Congress. In so doing, the Power Authority of the State of New York has been invited to present its views regarding potential impacts of an extended navigation season in the International Section of the Saint Lawrence River, albeit with some editorial restraints in keeping with the constraints imposed by available space. The same prerogative has been granted to and utilized by the Saint Lawrence Seaway Development Corporation.

The Committee has been unable to achieve a consensus on a detailed legal position although it has met several times, and certain members have worked very extensively on this legal appendix. There are differences of opinion on several legal issues discussed in the report and there is disagreement as to the conclusions. However, there is an unanimous consensus on the goal, which is to highlight the legal questions or problems.

In view of the diversity of interest involved, the Chairman of the Legal Committee has seen fit to set forth certain personal conclusions which are believed to be less partisan and which, hopefully, follow logically from the historical presentation contained in Section III, supra:

1. In the absence of explicit Congressional indication to the contrary, the provisions expressed in the Boundary Waters Treaty take precedence over domestic law.

2. Subject to the reservations preserved by the United States, it

is considered that modification of the ice booms in the International Section of the Saint Lawrence River is subject to the approval of the International Joint Commission. However, it is noted that a special agreement by Canada and the United States would obviate the need for Commission approval.

3. To the extent that PASNY's permitted authority to operate the ice booms impacts on United States waters, PASNY is subject to the authority of the Secretary of the Army.

4. The license granted to PASNY by the Federal Power Commission contains reservations in the interest of navigation. The Order of Approval of the International Joint Commission, dated 1952, contains reservations in the interest of navigation. The statute that created the power project in the Saint Lawrence River provides for the interests of navigation. It is believed that these various authorities sufficiently establish the proposition that the present power works in the Saint Lawrence River can be required to adapt to an extended navigation season.

5. The issues of responsibility for the ice booms and regulation of the ice control system during an extended navigation season remain to be resolved. Insufficient legal precedent exists to determine the exact resolution of these issues. Because it is believed that the IJC was created by the Treaty as a vehicle to prevent or resolve disputes, it is the opinion of the Chairman of the Legal Committee that resolution of these issues should be made by the IJC. Hearings by the IJC would create the proper forum for the advocacy which the members of the Legal Committee ably expressed and should aid the IJC in resolving the various remaining issues.

Respectfully submitted,

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ATTACHMENT A TO APPENDIX J

# WINTER NAVIGATION ON THE GREAT LAKES

# AND ST. LAWRENCE RIVER

SUBMITTED TO THE LEGAL COMMITTEE OF THE

WINTER NAVIGATION BOARD

BY THE POWER AUTHORITY OF THE

STATE OF NEW YORK

10 SEPTEMBER 1975

# M E M O R A N D U M

TO: LEGAL COMMITTEE OF THE WINTER NAVIGATION BOARD

FROM: POWER AUTHORITY OF THE STATE OF NEW YORK

DATE: SEPTEMBER 10, 1975

RE: WINTER NAVIGATION ON THE GREAT LAKES AND ST. LAWRENCE RIVER

## INTRODUCTION

Power Authority of the State of New York (Power Authority) hereby submits its final statement on the legal implications of the Winter Navigation Demonstration Program for the Great Lakes and St. Lawrence River as authorized in section 107(b) of Public Law 91-611 1/ as that program relates to Power Authority's St. Lawrence Hydroelectric Project (Project No. 2000). This statement presents the highlights of the legal history of the Power Authority's St. Lawrence Hydroelectric Project and delineates the salient legal problems raised by the program to demonstrate winter navigation on the river. In addition, suggested solutions are presented to the extent practicable. A short summary of this memorandum is also attached hereto as an Inclosure.

Power Authority's preliminary statement on the legal implications of the Winter Navigation Demonstration Program was previously submitted to the Legal Advisory Committee in the form of a draft memorandum dated April 1, 1975. A separate draft summary and conclusions was also submitted. Only minor revisions to that preliminary statement have been made in preparing this final statement.

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1/ Rivers and Harbors, Flood Control Acts of 1970, 84 Stat. 1818 (Dec. 31, 1970); as amended by § 70 of Public Law No. 93-251, 88 Stat. 12 (March 7, 1974).

## LEGAL HISTORY

Although international agreements and treaties between the United States and Canada governing the navigation and utilization of the Great Lakes and St. Lawrence River go back as far as 1854, 2/ the first important international legal document for the purpose of evaluating the unilateral, United States winter navigation demonstration program is the 1909 Convention Concerning the Boundary Waters Between the United States and Canada. 3/ The purpose of this Treaty is to prevent disputes regarding the use of boundary waters such as the St. Lawrence River and to establish a mechanism to provide for the adjustment and settlement of all questions regarding the use of boundary waters arising in the future. The mechanism established is, of course, the International Joint Commission (IJC), which presently has jurisdiction to approve all further or other uses or obstructions or diversions of boundary waters such as the St. Lawrence River affecting the natural level or flow therein. Under Article VIII the IJC is required to condition its approval in cases involving the elevation of the natural level of boundary waters upon adequate provisions for the protection and indemnity of all interests which may be injured thereby. Article VIII also establishes an order of precedence which must be observed among the various uses of boundary waters as follows:

"(1) Uses for domestic and sanitary purposes;
(2) Uses for navigation, including the service of canals for the purposes of navigation;
(3) Uses for power and for irrigation purposes."

In 1931 the Legislature of the State of New York created the Power Authority to effectuate its declared policy of developing the natural resources inherent in the St. Lawrence River for the use of commerce and navigation in the interest of the people of the State of New York and the

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2/ *See* Reciprocal Treaty of 1854; Treaty of Washington Between Great Britain and the United States, May 8, 1971.

3/ 36 Stat. 2448; T.S. 548; III Redmond 2607; S. Doc. No. 348 at 2607, 67th Cong., 1st Sess. (1923).

United States. 4/ The New York Legislature, however, clearly recognized the international nature of the St. Lawrence River since the Power Authority was directed to proceed with the improvement and development of the St. Lawrence River in cooperation with the proper Canadian authorities and was authorized and directed to apply to the appropriate agencies of the United States and Canada, including the Federal Power Commission (FPC) and the IJC, for such licenses, permits or approval as it deemed necessary or advisable. 5/

After years of extensive engineering and economic analysis, 6/ the Governments of Canada and the United States submitted applications to the IJC for approval of the construction by entities to be designated by the respective Governments of certain works for the development of power in the International Rapids Section of the St. Lawrence River. Pursuant to the terms of the 1909 Treaty, the IJC issued its Order of Approval on October 29, 1952, approving the construction, maintenance, and operation of certain works jointly by the Hydro-Electric Power Commission of Ontario (Ontario Hydro) and an entity to be designated by the Government of the United States in accordance with the 1942 Final Report of the Corps of Engineers on the "Controlled Single Stage Project (238-242)." The IJC Order also approved, in accordance with the joint application, the establishment by the Governments of Canada and the United States of a St. Lawrence River Joint Board of Engineers to review and, if authorized by both Governments, approve the plans and specifications of the works and the programs of construction thereof and to assure that the construction of the works was in accordance therewith. In addition, the IJC Order established an International St. Lawrence River Board of Control to insure compliance with the provisions of the Order relating to water levels and the regulation of the discharge of water from Lake Ontario and the flow of water through the International Rapids Section. In pertinent part the IJC conditioned its approval as follows: (1) <u>all</u> interests on either

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4/ Power Authority Act §1001; Ch. 772, Laws of New York, 1931, Approved April 27, 1931.

5/ *Id.* §1005(3).

6/ *See*, *e.g.*, U. S. Army Corps of Engineers, Final Report, St. Lawrence River Project (1942); Report of the Joint Board of Engineers on St. Lawrence Waterway Project (Nov. 16, 1926).

side of the International Boundary injured by reason of maintenance and operation of the works must be given suitable and adequate protection and indemnity in accordance with the laws of Canada or the laws of the United States, and the 1909 Treaty; (2) the works must be maintained and operated so as not to conflict with or restrain uses of the waters of the St. Lawrence River for purposes given preference over uses of water for power purposes by the Treaty, including uses for domestic and sanitary purposes; (3) the works must be maintained and operated in such manner as to safeguard the rights and lawful interests of others engaged in the development of power in the St. Lawrence River below the International Rapids Section; and (4) the works must be maintained and operated so as to safeguard so far as possible the rights of all interests affected by the levels of the St. Lawrence River upstream from the Iroquois Dam and by the levels of Lake Ontario and the lower Niagara River.

The 1942 Final Report of the Corps of Engineers on the "Controlled Single Stage Project (238-242)" demonstrates that Project No. 2000 was designed to permit formation of an ice cover and accordingly was not intended to accommodate navigation during winter months. It provides:

> "34. Ice is usually present on the St. Lawrence River from about the middle of December to the end of March, during which period navigation has to be suspended. Although this ice coverage is a hinderance to navigation, it is expected to be an advantage to power, as it will prevent the formation of frazil ice in the area which it covers and will also prevent floating ice from reaching the power house intake. Any reduction in frazil and floating ice reaching the power house will mean much less trouble with clogged racks and turbine passages, with resulting increased power generation. Experience with other hydro-plants in this latitude shows that considerable expense is warranted in maintaining an ice cover on the pool in the winter time. These factors undoubtedly influenced the Joint Committee to include in its 1941 recommendations a provision that constricted sections of the channel upstream from the power house be enlarged to lower winter velocities to the point where an ice cover will be secured. The exact criterion set up for carrying out this provision is discussed in more detail in Section IV.

"35. The basis for the criterion for ice cover was a study made by the Joint Board of Engineers in their 1926 report (Appendix E). This board found that an ice cover, or bridge, will form completely across the surface of a channel having an average velocity of less than 1-1/4 to 1-1/2 feet per second. Floating ice and slush will pack upstream therefrom against an average velocity of about 2-1/2 feet per second before the floating slush is drawn under the ice cover and will form downstream with velocities up to about 2 feet per second. As a result of this study, it was concluded that:

a. 'Smooth ice covers may be expected to form in rivers with velocities up to 1.25 feet per second in zero weather provided there is no high wind preventing such action.'

b. 'Ice covers may be expected to pack upstream up to a velocity of 2.25 feet per second without danger of ice going under the cover.'

These findings were accepted by the Joint Committee in their 1941 report and were made the basis of the present design. (See Section IV)." (Emphasis added). 7/

Furthermore, the 1926 Report of the Joint Board of Engineers on the St. Lawrence Waterway Project specifically recognized that in addition to necessary excavations to limit current velocities, ice booms could also be required to induce ice cover formation. That Report states:

"69. Between Chimney point and Butternut island, the ice situation is now variable. During some years an ice sheet forms across the river, in others an open channel leads through the section, either through the north channel or through the main channel on the south of Drummond island. After the improvement of this part of the river has been completed, conditions should be more

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7/ U.S. Army Corps of Engineers, Final Report, St. Lawrence River Project, Appendix A-2 at 34-35 (1942).

favorable for the formation of an ice sheet because of the enlargement to be made at Chimney point.

"70. It is proposed to deposit some of the waste rock from the excavation of the Chimney Point Channel to form artificial islands in shoal water at the sides of the natural channel opposite Drummond island, in order to assist in holding the ice sheet. Booms may also be employed to form an ice cover in this reach at the start of winter." (Emphasis added). 8/

Subsequent to issuance of the IJC Order of Approval, the FPC issued a license on July 15, 1953, 9/ to Power Authority under section 4(e) of the Federal Power Act 10/ authorizing construction, maintenance and operation of certain power facilities, designated as Project No. 2000, in the International Rapids Section of the St. Lawrence River. In its opinion accompanying the issuance of the license for Project No. 2000, the FPC recognized that Congress had provided the legal machinery whereby full authority for construction and operation would be secured within the United States through both the Boundary Waters Treaty of 1909 and the Federal Power Act. 11/ The FPC expressly found that the power development proposed by the Power Authority was predicated upon the 1942 Final Report of the United States Army Corps of Engineers on the St. Lawrence River Project referred to above. 12/ The FPC ordered, therefore, that the license be issued subject to the terms and conditions of the Federal Power Act which it incorporated by reference as a part of the license and, in addition, provided in Article 19 of the license that in the design, construction, maintenance and operation of the project, the licensee shall comply with all applicable provisions and requirements of the IJC Order of Approval. 13/

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8/ Report of Joint Board of Engineers on St. Lawrence Waterway Project at 248 (November 16, 1926).

9/ 12 FPC 172 (1953).

10/ 16 U.S.C. § 797(e) (1974).

11/ 12 FPC 172, 176 (1953).

12/ *Id.* at 180.

13/ *Id.* at 191.

In Executive Order No. 10,500, issued November 6, 1953, President Eisenhower declared Power Authority to be the designee of the United States to construct the proposed power project jointly with Canada. 14/

By an Exchange of Notes issued on November 12, 1953, the Governments of Canada and the United States concluded an International Agreement establishing the St. Lawrence River Joint Board of Engineers. This Agreement authorized the Joint Board of Engineers to perform the duties specified within the IJC Order of Approval including the approval of plans of the works and assurance that construction was in accordance with such approval. 15/

Based on the preceding legal framework, construction of the St. Lawrence Project was commenced. The two power entities spent nearly $90 million to excavate 63 million cubic yards in enlarging upstream channels to provide to the extent practicable an adequate cross section in the channel so that an ice cover would form in winter and to provide the desired navigation channels during open water. In accordance with the IJC Order of Approval, the channel enlargements downstream from Lotus Island were excavated to provide velocities not exceeding 2.25 feet per second during the ice forming period, the recognized maximum velocity beyond which ice packing would not occur. From Lotus Island upstream through the Galop reach to above Chimney Point, however, channel enlargements were designed only to provide velocities not exceeding 4 feet per second because it had always been considered uneconomic to excavate the Galop reach for ice packing velocities. Thus, as constructed it was possible that a hanging ice dam could develop at the leading edge of the packed cover if the supply of ice through the Galop reach became large.

Despite the above program of channel enlargements, a period of high wind and rising river levels dislodged large ice fields and led to the formation of an ice jam near Cardinal during the first winter of operation of the St. Lawrence project. This jam severely reduced flows (from

14/ 18 Fed. Reg. 7005.

15/ 5 U.S.T. 2538; T.I.A.S. 3116.

194,000 cfs to 151,000 cfs) into Lake St. Lawrence and consequently power generation, both at the Moses-Saunders Power Dam and at Beauharnois, was reduced as much as 20 percent. Fortunately, the involuntary storage of water resulting from this ice jam occurred when Lake Ontario was at a relatively low level and, therefore, no flooding problems were created during the spring of 1959.

After discussions with Hydro Quebec, model studies at Ontario Hydro's hydraulic laboratory, and prototype velocity surveys, it was concluded that floating ice booms offered the only feasible solution to eliminate massive ice movement and ensuing jams in the Cardinal area upstream from the Power Dam. Five ice booms were installed prior to the 1959-60 season pursuant to the authorization of the St. Lawrence River Joint Board of Engineers issued on September 1, 1959. A permit under section 10 of the Rivers and Harbors Act of 1899 16/ was also issued by the U.S. Army Corps of Engineers on December 22, 1959, to Power Authority authorizing placement of ice booms at specified locations in United States waters of the St. Lawrence River. A sixth boom was installed for the winter of 1960-61 pursuant to the authorization of the St. Lawrence River Joint Board of Engineers issued on August 4, 1960, and was relocated for the winter of 1961-62. The basic arrangement has remained unchanged since that time. However, the Joint Board of Engineers issued its authorizations subject to the condition that

> "Any significant modifications in the design or location of the booms that may be indicated by experience as being necessary, shall require approval by the Joint Board." 17/

Subsequently, the St. Lawrence River Joint Board of Engineers was dissolved after submitting its final report to the Governments of Canada and the United States on October 4, 1963.

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16/ 33 U.S.C. § 403 (1970).

17/ Letters from St. Lawrence River Joint Board of Engineers to Hydro-Electric Power Commission of Ontario, September 1, 1959 and August 4, 1960.

Recognizing that no formal international control over ice booms had been exercised since the dissolution of the Joint Board of Engineers, the IJC determined on January 14, 1974, that henceforth the six ice booms should be considered as included in the works approved by the IJC Order of Approval dated October 29, 1952, and subject to the IJC's jurisdiction to the same extent as though mentioned specifically in that Order. In addition, the IJC stated that the prior approvals granted by the Joint Board of Engineers would be considered IJC approvals and any amendments thereto would require approval of the IJC. By letters dated April 10, 1974, and August 5, 1974, respectively, the Governments of Canada and the United States concurred in the formal assumption of jurisdiction by the IJC over the six ice booms. The Power Authority was formally notified of IJC assumption of jurisdiction on October 11, 1974.

## WINTER NAVIGATION DEMONSTRATION PROGRAM

Under section 107(b) of Public Law No. 91-611 the Secretary of the Army, in cooperation with other Federal agencies, is authorized and directed to:

> " ... undertake a program to demonstrate the practicability of extending the navigation season on the Great Lakes and Saint Lawrence Seaway. Such program shall incude, but not be limited to, ship voyages extending beyond the normal navigation season; observation and surveillance of ice conditions and ice forces; environmental and ecological investigations; collection of technical data related to improved vessel design; ice control facilities, and aids to navigation; physical model studies; and coordination of the collection and dissemination of information to shippers on weather and ice conditions ... ."

The results of this program will be reported to Congress by December 31, 1976, but further program authorizations are a distinct possibility.

This program is conducted through the Winter Navigation Board consisting of several Federal agencies. Current scheduling plans recommended by the Board's Technical Review Panel contemplate installation of prototype booms in the Ogdensburg-Prescott reach and Ogden Island reach of the St.

Lawrence River in FY 77 and FY 78 respectively. Such experimental ice control facilities may seriously impair the functioning of Power Authority's ice boom system located in the same region of the river. The Power Authority is opposed to such feasibility experimentation without prior, adequate solution to the substantial legal problems which such activities raise.

## LEGAL PROBLEMS

In the context of the foregoing International and Federal legal framework, several legal problems are raised by the unilateral, United States winter navigation demonstration program. These problems may be addressed conveniently in terms of (A) additional required regulatory approvals and consultations, (B) the need for recognition of and provision for the potential liabilities of the Power Authority; and (C) recognition and protection of the substantial rights of the Power Authority and other potentially affected interests.

### A. REQUIRED REGULATORY APPROVALS

1. Under Article III of the 1909 Boundary Waters Treaty, IJC approval of the instant winter navigation demonstration program is required. Article III of the Treaty provides:

> "It is agreed that, in addition to the uses, obstructions, and diversions heretofore permitted or hereafter provided for by special agreement between the Parties hereto, <u>no further or other uses</u> or obstructions <u>or diversions, whether temporary or permanent, of boundary waters</u> on either side of the <u>line, affecting the natural level or flow of boundary waters on the other side of the line, shall be made except</u> by authority of the United States or the Dominion of Canada within their respective jurisdictions <u>and with the approval, as hereinafter provided, of a joint commission to be known as the International Joint Commission</u>." (Emphasis added).

The St. Lawrence is, of course, a boundary water under the Preliminary Article in the Treaty. It is well documented that the International Rapids Section of the St. Lawrence River was not used for the purpose of winter navigation at the time this Treaty was concluded or at the time the IJC issued its Order of Approval in connection with the St. Lawrence Project. Accordingly, winter navigation should be considered a "further or other" use within the meaning of Article III. Additionally, the instant winter navigation demonstration program includes ship voyages extending beyond the normal navigation season and experimentation with ice control facilities. 18/ Ship voyages near the closure of the navigation season in the Beauharnois Canal have produced a situation which resulted in a flow reduction from Lake Ontario, probably more drastic than would otherwise have occurred. 19/ Modification of existing ice control procedures and facilities on the St. Lawrence River above the Moses-Saunders Power Dam may also significantly affect the flow of the St. Lawrence River and the level of Lake Ontario. 20/ Thus, such actions should be considered as potentially "affecting the natural level or flow of boundary waters" within the meaning of Article III. Accordingly, it is concluded that in addition to the Congressional authorization contained in Public Law No. 91-611, which is also required under Article III of the Treaty, the instant winter navigation demonstration program requires the approval of the IJC.

Power Authority recognizes that uses for navigation purposes generally take precedence over uses for power purposes under Article VIII of the Treaty. Nevertheless, the 1952 IJC Order of Approval has already established a reasonable balance between such uses of the St. Lawrence River consistent with the Treaty's order of precedence. Obviously, Power Authority has made a substantial investment to develop a power use based upon the balance struck. At a minimum, therefore, IJC approval of the instant winter

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18/ Pub. L. No. 91-611, § 107(b) (Dec. 31, 1970).

19/ See Ad Hoc Committee on Ice Booms, International St. Lawrence River Board of Control, Addendum to Report of the Timing of Power Entities' Ice Boom Installation and Removal at 5-6 (March 15, 1974).

20/ See Power Authority of the State of New York, Ice and Power at 10-12.

navigation demonstration program, as a further navigation use altering the established balance, must be conditioned upon adequate compensation to Power Authority for any injury to its substantial power interest developed under existing IJC Orders of Approval.

2. Since the IJC has formally assumed jurisdiction over the ice booms in the St. Lawrence River, any significant modification thereto in connection with any winter navigation program or other purpose would require the approval of the IJC in accordance with its Order of Approval of October 29, 1952.

As noted above, the IJC determined on January 14, 1974, that the six ice booms should be considered as included in the works approved by its Order of Approval of October 29, 1952. This formal assumption of jurisdiction was concurred in by both Governments, and the power entities were notified of this formal determination on October 11, 1974. In pertinent part this notification states:

> "The Commission has formally determined that the six ice booms in the Prescott-Galop reach of the St. Lawrence River, which were approved by the St. Lawrence River Joint Board of Engineers in 1959 and 1960, henceforth will be considered as included in the works approved by this Commission's Order of Approval dated 29 October 1952 and subject to the Commission's jurisdiction to the same extent as though mentioned specifically in that order. The approvals given by the Joint Board of Engineers in their letters of September 1, 1959, and August 4, 1960, to the Power Entities ... will be considered International Joint Commission approvals and any amendments thereto will require the approval of this Commission." 21/

Thus, it is concluded that no significant, experimental modification of the six ice booms in order to facilitate any winter navigation program or other purpose is permitted without IJC approval thereof.

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21/ Letter from International Joint Commission to Power Authority of the State of New York, October 11, 1974.

3. The IJC Order of Approval also requires the Power Authority to obtain FPC approval of changes in the design of the ice booms or other works to facilitate any winter navigation demonstration program or other purpose.

Since the ice booms are considered "works" approved by the IJC Order of October 29, 1952, they are expressly subject to the conditions enumerated in that Order, including condition (f) which provides:

> "Before the Hydro-Electric Power Commission of Ontario commences the construction of any part of the works, it shall submit to the Government of Canada, and before the entity designated by the Government of the United States commences the construction of any part of the works, it shall submit to the Government of the United States, for approval in writing, detailed plans and specifications of that part of the works located in their respective countries and details of the program of construction thereof or such details of such plans and specifications or programs of construction relating thereto as the respective Government may require. If after any plan, specification or program has been so approved, the Hydro-Electric Power Commission of Ontario or the entity designated by the Government of the United States wishes to make any change therein, it shall, before adopting such change, submit the changed plan, specification or program for approval in a like manner."

The Power Authority is, of course, the entity designated by the Government of the United States. The Power Authority's detailed plans and specifications for the project were approved by the FPC, the responsible agency of the Government of the United States, in accordance with the provisions of the Federal Power Act. In its order issuing the license for Project No. 2000, the FPC expressly found that the proposed project would consist of, inter alia, all structures, equipment, or facilities used in the maintenance and operation of the project area, including such portable property as may be useful in connection wtih the project or any part thereof, whether located on or off the project area, if and to the extent that the inclusion of such property as part

of the project was approved or acquiesced in by the FPC. 22/ Accordingly, before adopting any change in any plan, specification, or program, including those pertaining to the six ice booms, the Power Authority is required by condition (f) of the IJC Order of Approval to obtain FPC approval thereof under the Federal Power Act.

4. The Exchange of Notes of August 17, 1954, between the United States and Canada requires consultation with the Government of Canada with respect to the instant winter navigation demonstration program.

By that Exchange of Notes the United States and Canada effected an international agreement concerning navigation on the St. Lawrence River. 23/ This agreement was necessitated by the Congressional enactment of Public Law 358 on May 13, 1954, 24/ which created the St. Lawrence Seaway Development Corporation and authorized and directed it to construct 27-foot navigation works on the United States side of the International Section of the St. Lawrence River. The commitments made therein by the respective Governments are in addition to the Treaty obligations otherwise relevant. 25/

The additional undertakings are contained in paragraph 4(b) and 6 of the Canadian Note of August 17, 1954. Under paragraph 4(b) the United States Government is required to consult the Canadian Government should the United States Government intend to build on United States territory in the International Rapids Section "navigation works" in addition to those provided for in Public Law 358.

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22/ 12 FPC 172, 181 (1953)

23/ 5 U.S.T. 1784; T.I.A.S. 3053.

24/ 33 U.S.C. § 981 *et seq*. (1970).

25/ Canadian Note of August 17, 1954, paragraph 6d, 5 U.S.T. at 1787.

Paragraph 6(b) provides:

> "It is further agreed that each Government will consult the other before it enacts any new law or promulgates any new regulation, applicable in the respective national parts of the international section of the St. Lawrence River, which might affect Canadian or United States shipping, or shipping of third-country registry proceeding to or from Canada or the United States respectively." 26/

Thus, it is recommended that present and proposed legislation authorizing any winter navigation program be reviewed in the context of the foregoing requirements in order that any necessary consultation by the Government of the United States with the Government of Canada be commenced without further delay as required by this agreement.

In this regard it is worthwhile to note that the enabling legislation creating the St. Lawrence Seaway Development Corporation requires that Corporation to coordinate its navigation activities with Canadian navigation authorities and the Power Authority. Section 3(b) of Public Law 358 provides:

> "The Corporation shall make necessary arrangements to assure the coordination of its activities with those of the St. Lawrence Seaway Authority of Canada and the entity designated by the State of New York, or other licensee of the Federal Power Commission, authorized to construct and operate the dams and power works authorized by the International Joint Commission in its order of October 29, 1952 (docket 68) or any amendment or modification thereof." 27/

The foregoing is confirmed by reference to the legislative history of Public Law 358. 28/

5. The Federal Power Act independently requires the Power Authority to obtain prior FPC approval for any substantial alteration to any project works made in connection with the winter navigation demonstration program.

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26/ Id. at 1786.

27/ 33 U.S.C. § 983(b) (1970).

28/ 1954 U.S. Code Cong. & Ad. News at 2199-2200.

Section 10 of the Federal Power Act 29/ requires that all licenses issued by the FPC shall contain the conditions enumerated therein. In particular, section 10(b) provides:

> "That except when emergency shall require for the protection of navigation, life, health or property, no substantial alteration or addition not in conformity with the approved plans shall be made to any dam or other project works constructed hereunder of an installed capacity in excess of 2,000 horsepower without the prior approval of the Commission; and any emergency alteration or addition so made shall thereafter be subject to such modification and change as the Commission may direct." 30/

In issuing the license for Project No. 2000 to the Power Authority, the FPC specifically incorporated this condition in the license under Article 3 thereof. 31/

The meaning of "project" and "project works" is readily determined from the Federal Power Act definitions and the FPC order issuing the Power Authority's license. Section 3(12) provides:

> "'project works' means the physical structures of a project." 32/

In addition, section 3(11) provides:

> "'project' means complete unit of improvement or development, consisting of a power house, all water conduits, all dams and appurtenant works and structures (including navigation structures) which are a part of said unit, and all storage diverting or forebay reservoirs directly connected therewith ... all miscellaneous structures used and useful in connection with said unit or any part

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29/ 16 U.S.C. § 803 (1974).

30/ Id. § 803(b).

31/ 12 FPC at 186.

32/ 16 U.S.C. § 796(12) (1974).

thereof, and all water rights, rights of way, ditches, dams, reservoirs, lands, or interest in lands the use and occupancy of which are necessary or appropriate in the maintenance and operation of such unit." 33/

Accordingly, in issuing the Power Authority's license the FPC expressly found that:

"The proposed project would consist of:

* * * *

C. All other structures, fixtures, equipment, or facilities used or useful in the maintenance and operation of the project and located on the project area, including such portable property as may be used or useful in connection with the project or any part thereof, whether located on or off the project area, if and to the extent that the inclusion of such property as part of the project is approved or acquiesced in by the Commission, also all riparian or other rights, the use or possession of which is necessary or appropriate in the maintenance or operation of the project." 34/ (Emphasis added).

Power Authority concludes, therefore, that the six ice booms, as portable property useful in connection with the project, and Lake St. Lawrence, as a forebay reservoir, are "project works" within the meaning of the Federal Power Act and the Power Authority's license. Consequently, substantial alteration thereto is prohibited without prior FPC approval pursuant to section 10(b) of the Federal Power Act.

Because of the potentially grave consequences of ice control experimentation, FPC approval of a substantial alteration to the Power Authority's ice booms or other project works would be major Federal action significantly affecting the quality of the human environment under the National Environmental Policy Act of 1969 (NEPA), 42 U.S.C. § 4321

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33/ Id. § 796 (11).

34/ 12 FPC at 180-181.

et seq. Thus, in issuing its approval the FPC would be required to prepare a detailed environmental impact statement in accordance with the procedural mandate of section 102(2)(C) of NEPA and FPC regulations. In addition, NEPA is clearly more than an environmental full disclosure law. Compliance with NEPA's substantive policies as well as its procedural mandate would also be required in connection with FPC approval. Environmental Defense Fund v. Corps of Engineers, 470 F.2d 289, 297 (8th Cir. 1972), cert. denied, 412 U.S. 931 (1973).

The exercise of FPC jurisdiction over alterations to project works pursuant to the Power Act and NEPA is illustrated by the FPC Order of March 13, 1975, requiring South Carolina Public Service Authority, the licensee for Project No. 199, to cease "or caused to have ceased" construction activities involving, inter alia, alterations of project works which have not been specifically approved by the FPC. This Order was issued after the FPC discovered that numerous applications had been filed with the Corps of Engineers by the licensee and third parties for permits to perform various construction activities within Project No. 199. Through this action the FPC has underscored the responsibility of a FPC licensee, such as Power Authority, for the activities of third parties affecting project works. Based upon this Order and the applicable provisions of the Federal Power Act, Power Authority concludes that is has a duty under its license to protect its project works from substantial alterations or interference that might be occasioned by the acts of third parties until the Power Authority obtains the prior approval of the FPC.

6. Through Article 19 of the Power Authority's license, the Federal Power Act precludes modifications to the ice booms inconsistent with the IJC Order of Approval.

The legal machinery whereby the full authority for construction and operation of Project No. 2000 was secured within the United States is derived from both the Boundary Waters Treaty of 1909 and the Federal Power Act. 35/ Therefore, the FPC provided in Article 19 of the Power Authority's license that:

> "In the design, construction, maintenance and operation of the project covered by this license, the licensee shall comply with all applicable provisions and requirements of the order of ap-

35/ Id. at 176.

proval (International Joint Commission docket 68) issued October 29, 1952, by the International Joint Commission ... for the construction of certain works for the development of power in the International Rapids section of the St. Lawrence River." 36/

The IJC has formally determined that the six ice booms are "works" within the meaning of the IJC Order of Approval. Therefore, under the provisions of the Federal Power Act 37/ and Article 19, the Power Authority may not take action or acquiesce in the actions of others with respect to the ice booms inconsistent with the provisions and conditions of the IJC Order of Approval without incurring the risk of losing its license.

7. The proposed ice control experimentation may impair Power Authority's ability to comply with the FPC Order of August 3, 1959.

The FPC Order of August 3, 1959, 22 FPC 185, 186, requires Power Authority to comply with all applicable provisions of the IJC Order of Approval issued October 29, 1952, as amended by the IJC Order of July 2, 1956, in the maintenance and operation of Project No. 2000. The FPC Order alsc provides:

"In complying with these requirements, the licensee shall be deemed to have accomplished such compliance if it follows Regulation Plan 1958-A or any supplementary or superseding plan of regulation approved by the International Joint Commission, under supervision of the International Saint Lawrence River Board of Control in accordance with paragraph (h) of the October 29, 1952, Order of Approval."

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36/ *Id.* at 191.

37/ Section 26, 16 U.S.C. § 820, provides:

"That the Attorney General may, on request of the Commission or of the Secretary of the Army, institute proceedings in equity in the district court of the United States in the district in which any project or part thereof is situated for the purpose of revoking for violation of its terms any permit or license issued hereunder, or for the purpose of remedying or correcting by injunction, mandamus or other process any act of commission, or omission in violation of the provisions of this Act or of any lawful regulation or order promulgated hereunder."

The IJC has approved Regulation Plan 1958-D pertaining to the regulation of Lake Ontario levels and outflows. Thus, Power Authority is deemed in compliance with the FPC Order of August 3, 1959, so long as it follows Regulation Plan 1958-D. Introduction of experimental ice control structures by the Winter Navigation Board such as those proposed by the Technical Review Panel for FY 77 and FY 78 in the Ogdensburg-Prescott reach and Ogden Island reach may significantly impair Power Authority's ability to meet the requirements of Regulation Plan 1958-D. In such event, Power Authority would not necessarily be deemed in compliance with the FPC Order of August 3, 1959. It is, however, fundamental that Power Authority conduct its activities within the mandate of this FPC Order.

8. Since FPC authority over the ice booms and other project works under the Federal Power Act preempts Corps of Engineers permit authority under section 10 of the Rivers and Harbors Act of 1899, the Corps of Engineers is without jurisdiction to issue a permit under the Rivers and Harbors Act independently authorizing any modifications to Power Authority project works.

Under section 10 of the Rivers and Harbors Act of 1899, 33 U.S.C. § 403, structures or work may not be commenced in navigable waters of the United States unless approved by the Corps of Engineers. However, under section 23(b) of the Federal Power Act, 38/ which was enacted subsequently to the Rivers and Harbors Act, the construction of any dam or works incidental thereto across, along, or in any navigable water is declared unlawful except in accordance with a license issued by the FPC pursuant to section 4 of the Federal Power Act. In pertinent part, section 4(e) of the Power Act provides:

> "That no license affecting the navigable capacity of any navigable waters of the United States shall be issued until the plans of the dam or other structures affecting navigation have been approved by the Chief of Engineers and Secretary of the Army." 39/

Thus, obtaining a permit from the Corps of Engineers under section 10 of the Rivers and Harbors Act would clearly result in duplication of Federal administrative effort. More-

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38/ 16 U.S.C. § 817 (1974).

39/ *Id.* § 797(e).

over, it is recognized that the central purpose of the Federal Power Act is to provide the FPC with the comprehensive control over those uses of the nation's water resources in which the Federal government has a legitimate interest, including navigation, irrigation, flood control and hydroelectric power. FPC v. Union Electric Co., 381 U.S. 90 (1965). The foregoing led the court in Scenic Hudson Preservation Conference v. Callaway, 370 F. Supp. 162 (S.D.N.Y. 1973), aff'd, 499 F.2d 127 (2d Cir. 1974), to hold that in view of the broad FPC responsibility for such comprehensive development and the inter-agency review mandated by section 4(e), the Federal Power Act preempts the Corps of Engineers' permit authority under section 10 of the Rivers and Harbors Act for structures and work authorized by a FPC license. The court ruled, therefore, that a utility was not required to obtain a section 10 permit from the Corps independently authorizing work in a navigable water undertaken in connection with construction of a hydroelectric project already approved under a FPC license. In so holding the court also explicitly approved Corps of Engineers regulations in this regard, which provide:

> "In such cases, the interests of navigation should normally be protected by a recommendation to the FPC for the inclusion of appropriate provisions in the FPC license rather than the issuance of a separate Department of the Army permit under 33 U.S.C. § 401, et seq." 40/

Therefore, Power Authority concludes that overall Federal regulatory responsibility for the ice booms in United States waters is vested in the FPC, and the Corps of Engineers, by virtue of such preemption, is without jurisdiction to independently permit, pursuant to section 10 of the Rivers and Harbors Act, modification or additions thereto. Thus in connection with Project No. 2000, Corps of Engineers authority to regulate navigation must be exercised within the constraints of the Federal Power Act.

### B. LIABILITIES OF THE POWER AUTHORITY

Any winter navigation demonstration program must recognize and make adequate provision for the extensive liability of the Power Authority which could arise under the 1909 Boundary Waters Treaty, the IJC Order of Approval

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40/ 33 C.F.R. § 209.120(c)(6)(1974).

issued thereunder, and the provisions of the Federal Power Act if the Power Authority were to voluntarily remove or impair the protection now provided by the ice booms.

The IJC Order approved construction, maintenance and operation of the works subject to several conditions. Condition (a) provides:

> "All interests on either side of the International Boundary which are injured by reason of the construction, maintenance, and operation of the works shall be given suitable and adequate protection and indemnity in accordance with the laws in Canada or the Constitution and laws in the United States respectively, and in accordance with the requirements of Article VIII of the Treaty."

In addition, condition (d) provides:

> "The works shall be so designed, constructed, maintained and operated as to safeguard so far as possible the rights of all interests affected by the levels of the St. Lawrence River upstream from the Iroquois regulatory structure and by the levels of Lake Ontario and the lower Niagara River; and any change in levels resulting from the works which injuriously affects such rights shall be subject to requirements of [condition (a)] relating to protection and indemnification."

As noted above, Article 19 of the Power Authority's FPC license requires the Power Authority to abide by these conditions.

Section 10(c) of the Federal Power Act provides in pertinent part:

> "Each licensee hereunder shall be liable for all damages occasioned to the property of others by the construction, maintenance, or operation of the project works or of the works appurtenant or accessory thereto, constructed under the license, and in no event shall the United States be liable therefor." 41/

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41/ 16 U.S.C. § 803(c) (1974).

In addition, section 27 of the Federal Power Act provides:

> "That nothing herein contained shall be construed as affecting or intending to affect or in any way interfere with the laws of the respective states relating to the control, appropriation, use or distribution of water used in irrigation or for municipal or other uses, or any vested right acquired therein." 42/

These provisions have been construed by the courts to require a licensee such as the Power Authority to pay just compensation for destruction of, or interference with, vested water rights and other property interests held under State law. FPC v. Niagara Mohawk Power Corp., 347 U.S. 239 (1954); Henry Ford & Son, Inc v. Little Falls Fibre Co., 280 U.S. 269 (1930); Portland General Electric Co. v. FPC, 328 F.2d 165 (9th Cir. 1964).

For example, in U.S. v. Central Stockholders Corp., 52 F.2d 323 (9th Cir. 1931), the FPC licensee was held liable to a lower riparian proprietor for interference with its riparian rights to the annual overflow of waters of the San Joaquin River, which constituted vested rights protected under State law. In Henry Ford & Son, Inc. v. Little Falls Fibre Co., supra, the Supreme Court held that a licensee under the Federal Power Act was liable to an upper riparian owner whose water power rights had been partially taken as a consequence of the licensee's activities. Later, in FPC v. Niagara Mohawk Power Corp., supra, the Supreme Court reiterated that vested State water rights had not been abolished by the Federal Power Act and such rights may not be taken without compensation. Although the Court recognized the dominant servitude in favor of the United States under which all private persons hold all rights to use the water of navigable streams, it emphasized that the exercise of that servitude without making allowance for preexisting rights requires a clear authorization lacking in the Federal Power Act. Thus, the Court concluded that the FPC licensee was justified in making payments for a vested right to water power acquired under State law.

Other property interests are protected under section 10(c) of the Federal Power Act. In Seaboard Airline R. Co. v. Crisp County, 279 F.2d 873, cert. denied, 364 U.S. 942 (1961), the court held that a FPC licensee was liable

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42/ Id. § 821.

for all damages inflicted upon a railroad embankment as a result of both construction and operation of a hydroelectric project. In Grand River Dam Authority v. Board of Education, 147 P.2d 1003, cert. denied, 322 U.S. 733 (1944), the court held that the FPC licensee was liable to a school district where the impoundment of waters caused damages to school property.

The Power Authority's potential liability would not be limited to injuries inflicted upon properties located within the United States. In pertinent part Article VIII of the Treaty provides:

> "The Commission in its discretion may make its approval in any case conditional upon the construction of remedial or protective works to compensate so far as possible for the particular use or diversion proposed, and in such cases may require that suitable and adequate provision, approved by the Commission, be made for the protection and indemnity against injury of any interests on either side of the boundary.
>
> "In cases involving the elevation of the natural level of waters on either side of the line as a result of the construction or maintenance on the other side of remedial or protective works or dams or other obstructions in boundary waters or in waters flowing therefrom or in waters below the boundary in rivers flowing across the boundary, the Commission shall require as a condition of its approval thereof, that suitable and adequate provision, approved by it, be made for the protection and indemnity of all interests on the other side of the line which may be injured thereby."

Pursuant to this authority the IJC has attached condition (a), as quoted supra, to its Order of Approval, explicitly protecting "all interests on either side of the International Boundary" in accordance with, inter alia, the Constitution and laws of the United States. Accordingly, if Power Authority agreed or acquiesced in changes in the ice booms to facilitate any winter navigation demonstration program in United States waters, those Canadian property interests injured thereby may also recover damages under section 10(c) of the Federal Power Act.

The foregoing adequately demonstrates that if the Power Authority voluntarily agreed or acquiesced in substantial changes or removal of the ice booms to facilitate a winter navigation demonstration program, it could be liable for injuries to recognized property interests on either side of the International Boundary resulting from such maintenance or operation of the project works. Winter operation of Project No. 2000 without ice booms resulted in the formation of large ice jams which dramatically reduced the outflow of Lake Ontario in 1959. In a year of high inflows into Lake Ontario, such an outflow reduction would cause the level of water in Lake Ontario to rise and cause serious flooding and other shoreline damage. Substantial experimental modification of the ice boom configuration may cause the same results. The seriousness of the potential liability is underscored by the damage caused by recent flooding on Lake Ontario from other causes. The total damage caused by just one day of flooding was alleged to be approximately $50 million. This should be compared with the Power Authority's annual revenues from Project No. 2000 of $27 million.

The foregoing focuses upon the Power Authority's potential liability under the Federal Power Act and 1909 Treaty. Of course, adequate provision for the corresponding potential liability of Ontario Hydro under Canadian law is also required.

## C. RIGHTS OF POWER AUTHORITY

Significant ice control experimentation proposed in the winter navigation demonstration program may not be implemented without adequate protection for the Power Authority's rights arising under the Treaty and the Federal Power Act.

First, under Article III of the Treaty, experiments to demonstrate winter navigation may constitute a further use affecting at least temporarily the natural level or flow of boundary waters which requires IJC approval. Thus, under Article VIII the IJC is required to condition its approval thereof upon suitable and adequate provision for the protection and indemnity of all interests which may be injured thereby. Such interests must include the right of the Power Authority as a licensee under the Federal Power Act to utilize the hydroelectric potential of the St. Lawrence River. Accordingly, the Power Authority would be entitled to compensate for lost revenues caused by reduced output resulting from any winter navigation demonstration program.

As a licensee under the Federal Power Act, the Power Authority has substantial rights thereunder which must be protected. The license for Project No. 2000 was issued by the FPC for a period of fifty (50) years and properly accepted by the Power Authority. Consequently, the Power Authority is entitled to operate and maintain Project No. 2000 in accordance with the provisions of the Federal Power Act and the conditions of the license. The circumstances under which the conditions in its license and the provisions of the Power Act may be modified are sharply circumscribed to protect the Power Authority. Section 6 of the Power Act provides:

> "Licenses may be revoked only for the reasons and in the manner prescribed under the provisions of this Act, and may be altered or surrendered only upon mutual agreement between the licensee and the Commission after thirty days' public notice." 43/

In addition, section 28 thereof also provides:

> "That the right to alter, amend, or repeal this Act is hereby expressly reserved; but no such alteration, amendment, or repeal shall affect any license theretofore issued under the provisions of this Act, or the rights of any licensee thereunder. 44/

As the court in Scenic Hudson Preservation Conference v. Callaway 45/ recognized, section 28 is intended to protect licensees from *ex post facto* lawmaking relating specifically to FPC license requirements.

Under Article 12 of the license for Project No. 2000, at a minimum, the rules and regulations pertaining to the operation of any navigation facilities must be reasonable. 46/

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43/ *Id.* § 799.

44/ *Id.* § 822.

45/ 370 F. Supp. at 171.

46/ 12 FPC at 189.

Although the United States has specifically retained the right under Article 13 to use water in an amount necessary for the purposes of navigation, the licensee also has, at the very least, the right thereunder to insist upon reasonable rules and regulations in the interest of navigation which also protect life, health, and property, and the interest of the fullest practicable conservation and utilization of such waters for power purposes. 47/

Under the provisions of the Federal Power Act, which are incorporated by reference into the license for Project No. 2000, the Power Authority, as well as other affected interests, has the right to require that Project No. 2000 continue to be best adapted to a comprehensive plan for improving or developing the St. Lawrence River for the uses of commerce, water power development, and other beneficial public uses. 48/

Any proposed winter navigation demonstration program must accordingly be evaluated in terms of the foregoing legal rights.

Respectfully submitted,

POWER AUTHORITY OF THE STATE
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47/ Id.

48/ 16 U.S.C. §803(a) (1974).

INCLOSURE TO ATTACHMENT A

## SUMMARY OF POWER AUTHORITY OF THE STATE OF NEW YORK MEMORANDUM TO THE LEGAL COMMITTEE OF THE WINTER NAVIGATION BOARD

The legal framework underlying Power Authority's Project No. 2000 comprises a complex, interrelated structure of Federal and International Law based upon the Federal Power Act and the 1909 Convention Concerning the Boundary Waters Between the United States and Canada (1909 Treaty).

Under the 1909 Treaty the International Joint Commission (IJC) approved, on October 29, 1952, the construction, maintenance and operation of the works comprising Project No. 2000 in accordance with the applications of the Governments of Canada and the United States. This Order of Approval also authorized establishment of a St. Lawrence Joint Board of Engineers to review and approve plans, specifications and programs of construction of the project and established an International St. Lawrence River Board of Control to insure compliance with the conditions of the IJC Order of Approval concerning the flow of water through the International section of the St. Lawrence and the discharge of water from Lake Ontario.

The IJC issued its approval upon several conditions of great significance to the winter navigation demonstration program, including (1) adequate protection and indemnity under Canadian and United States law for all interests injured through operation of the works, and (2) operation of the works in a manner that safeguards the development of power below the International Rapids Section and avoids restraint of uses given preference over uses for power purposes by the Treaty, including uses for domestic and sanitary purposes and navigation purposes.

As approved by the IJC, Project No. 2000 was designed to induce formation of a stable ice cover and thus was not intended to accommodate navigation during the winter months. Ice cover formation was to be accomplished through channel excavations upstream from the power dam to lower winter flow velocities to the point where ice packing would secure a cover. The utilization of ice booms as a supplementary control measure was anticipated as early as 1926.

Power Authority was issued a license under the Federal Power Act for Project No. 2000 on July 15, 1953. All of the terms and conditions in the Federal Power Act were incorporated therein by reference. In addition, Article 19 of the License provides that Power Authority shall comply with the IJC Order of Approval of October 29, 1952, in the design, construction, maintenance and operation of the project. Subsequently, on August 3, 1959, the Federal Power Commission (FPC) ordered Power Authority to comply with the foregoing IJC Order of Approval as amended by the IJC Order of July 2, 1956, in the maintenance and operation of the project. This FPC Order specified that Power Authority is deemed in compliance if it follows Regulation Plan 1958-A or any superseding plan of regulation approved by the IJC, under the supervision of the International St. Lawrence River Board of Control.

Despite extensive channel enlargements costing the power entities nearly $90 million, an ice jam formed during the first winter of operation which severely reduced flows into Lake St. Lawrence from Lake Ontario. Analysis showed that floating ice booms offered the only feasible solution to this problem. Therefore, six booms, authorized by the Joint Board of Engineers in 1959 and 1960, are installed each winter in the International Rapids section to eliminate massive ice movement and jams upstream from the Moses-Saunders Power Dam. The booms were authorized subject to the condition that any significant modifications in design or location would require additional approval of the Joint Board. Since this Board was dissolved in 1963, the IJC formally determined that these ice booms are "works" within the meaning of its Order of Approval, that Joint Board approvals would be considered IJC approvals, and that any amendment thereto would require additional IJC approval.

The winter navigation demonstration program includes experimentation with ice control facilities in the St. Lawrence River and ship voyages extending beyond the normal navigation season. Such activities may seriously impair the function of Power Authority's ice boom system and cause formation of dangerous ice jams. Resulting reduced flows into Lake St. Lawrence would lower its level, reduce power output, and raise the level of lake Ontario to flood stages causing significant property damage. The Power Authority must oppose such activities undertaken without prior adequate solution of the substantial legal problems

raised by such proposals. These problems include additional regulatory approvals and consultations and provision for the potential liabilities and rights of Power Authority and other affected interests.

Additional regulatory approvals and consultations include:

1. IJC approval of the entire winter navigation demonstration program as a further use affecting the natural level or flow of boundary waters under Article III of the 1909 Treaty;

2. IJC approval of modification to the Power Authority's ice booms as works under the IJC Order of Approval of October 29, 1952;

3. FPC approval of changes in the ice booms or other works pursuant to condition (f) of the IJC Order of Approval.

4. Consultation with the Government of Canada with respect to construction of navigation works and enactment of new laws affecting shipping on the St. Lawrence River pursuant to the Exchange of Notes between the United States and Canada on August 17, 1954;

5. FPC approval of substantial alterations to any project works such as the ice booms or Lake St. Lawrence pursuant to section 10(b) of the Federal Power Act, Article 3 of the license for Project No. 2000, and the National Environmental Policy Act of 1969;

6. Appropriate modification of Article 19 of the license, which is enforceable through section 26 of the Federal Power Act and presently requires compliance with all applicable provisions of the IJC Order of Approval issued October 29, 1952; and

7. Appropriate modification of the FPC Order of August 3, 1959, requiring Power Authority to comply with any currently effective regulation plan.

Adequate provision for Power Authority's potential liabilities is mandatory. Article 19 of the license requires Power Authority to comply with the conditions of the IJC Order of Approval requiring protection and indemnity of all interests on either side of the boundary injured by construction, maintenance and operation of the project in accordance with, *inter alia*, the laws of the United States. Under section 10(c) of the Federal Power Act, Power Authority could be liable for damages caused to the property of others, including vested water rights under State law, if it were to agree voluntarily or acquiesce in removal or impairment of the protection now afforded by its ice booms. Section 10(c) also explicitly provides that in no event shall the United States be liable for such damages. There is ample authority demonstrating that the courts will construe these provisions to give full indemnity for the destruction of or interference with vested water rights for power or other riparian uses and other recognized property interests caused by maintenance or operation of a FPC licensed project. The gravity of potential liability is underscored by the damage recently caused by one day of flooding on Lake Ontario from other causes. The total damage estimate was alleged to be approximately $50 million. By contrast, Power Authority's annual revenues from Project No. 2000 are $27 million.

Adequate protection of Power Authority's rights and the rights of others is also required. Power Authority recognizes the precedence of navigation uses over power uses under Article VIII of the 1909 Treaty. However, the IJC Order of Approval of 1952 has established a reasonable balance among such uses consistent with the Treaty's order of precedence. Changes in this balance to facilitate winter navigation must be conditioned upon compensation to Power Authority for any injury to its substantial power investment, which is predicated upon the 1952 Order of Approval. Moreover, under Article VIII of the 1909 Treaty the IJC must condition its approval of further uses affecting the natural level or flow of boundary waters upon adequate provision for the protection and indemnity of all interests which may be injured thereby. Such interests include the right of Power Authority as a FPC licensee to utilize the hydroelectric potential of the St. Lawrence River.

In addition to its obligations as a licensee, Power Authority has extensive rights under the Federal Power Act. The conditions of its license may be altered only upon mutual agreement between Power Authority and the FPC. No subsequent amendment of the Federal Power Act may affect the Power Authority's license or the rights of Power Authority thereunder. These rights include Power Authority's substantial financial interest in operating and maintaining the project in a mode that continues to be best adapted to the comprehensive plan for developing the St. Lawrence River for all beneficial public uses.

ATTACHMENT B TO APPENDIX J

# LEGAL CONSIDERATIONS RELATIVE TO THE WINTER NAVIGATION PROGRAM IN THE ST. LAWRENCE RIVER

Prepared By

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General Counsel

Saint Lawrence Seaway Development Corporation

April 4, 1975

INTRODUCTION

At the signing of Public Law 358, which brought into existence the Saint Lawrence Seaway Development Corporation, Congressman Dondero, a co-author of the bill, noted:

> "Mr. President, the people of the United States, through their Congress, have determined that they will participate with their good neighbor to the north, Canada, in the construction of the St. Lawrence seaway. It has been the dream of many decades. It is one of the greatest waterways in the world, and will be one of the great arteries of commerce in the world. I think that it will contribute much to the economic welfare and also to the national defense of both the United States and Canada.
>
> "Mr. President, five of your predecessors advocated and endorsed the building of the St. Lawrence Seaway. It has been delayed 30 or 40 years, and now under your great leadership this mighty project, the master project of the North American Continent, is to become a reality.
>
> "I want to add just one more thought, and that is this: that in the days to come, the American people, the Canadian people, the Continent of North America, will receive great benefit from what we are doing now.
>
> "I am proud to be a Member of the 83d Congress, to have had some part in bringing this very happy day about, as chairman of the Committee on Public Works of the House of Representatives.
>
> "To you, Mr. President, and your administration, must go the credit for bringing about the beginning of this great project. Only one thing remains now, to make the seaway an assured fact, and that is your signature to the bill before you." (White House press release, May 13, 1954.)

It is now recognized that in order to fulfill the tremendous potential of the St. Lawrence Seaway as envisioned by Mr. Dondero and his colleagues, a method for extending the period of navigation on the St. Lawrence River must be found. Former Department of Transportation

Secretary Volpe, in voicing his support for increased emphasis in this area, stated:

* * * * *

> "Our long-range goal in extending the Seaway navigation season could perhaps even mean year-round operations of this vital waterway. This would mean greater utilization of this important mode of transportation. We believe lengthening the Seaway season is both possible and feasible. I remind you the shipping season on the Great Lakes originally lasted about seven and a half months. Now it is approximately ten months long. We shall do better.
>
> "The demand for a longer season has been most evident during the past few weeks when a record number of ships entered the Seaway -- so many in fact that we had to set up special procedures to get them out before yesterday's official closing. The Seaway is in demand."

* * * * *

> "This extension of the Seaway navigation season implements President Nixon's demand for increased utilization of our 4th Seacoast....."

* * * * *

As part of an intergovernmental season extension program, and in furtherance thereof, the Saint Lawrence Seaway Development Corporation (SLSDC) installed a gate in an ice boom belonging to The Power Authority of the State of New York (PASNY), the use of such gate, coupled with limited ice breaking, allowing the St. Lawrence River to be navigated while at the same time insuring the presence of an ice cover. The apparent necessity for an ice cover so as to insure maximum power generation precipitated in the late 1950's the installation of booms across the navigation channel thereby totally eliminating the navigability of the river. The fruition of this rather far-reaching and progressive

proposal has not come easily nor quickly. In proclaiming the power entity's deep concern for such activities, the Chairman of PASNY has stated:

* * * * *

"The Power Authority does not object to extension of the navigation season if this can be accomplished without disrupting ice control measures that protect property owners and power production on the Niagara and St. Lawrence rivers. However, we see no acceptable substitute for current ice control procedures along the St. Lawrence.

* * * * *

"Control of ice for the protection of all interests requires maintenance of a stable ice cover over the St. Lawrence River throughout the winter. This prevents formation of additional ice in quantities that will result in jamming and flooding upstream of the jam. Ice booms have been successful instruments for such controls.

* * * * *

"If the Power Authority is to continue to share with Ontario Hydro the responsibility for operating the St. Lawrence project and safeguarding the rights of both upstream and downstream interests, it must continue ice control procedures in which the ice booms are closed prior to the onset of ice formation and the booms remain in place until the reasonable possibility of ice movement and packing has passed in the spring. As indicated these procedures have not interfered with navigation in the past.

"Before proceeding with ice breaking experiments that may produce serious damage to other interests on the St. Lawrence River, those involved should recognize and assert their willingness to shoulder full legal and financial responsibility for the effects of such experimentation upon shore properties, power and other interests.

* * * * *

"In summary, the Authority regrets that after having given serious consideration and study to the proposals made by the Seaway Corporation and after conferring with the Hydro-Electric Power Commission of Ontario, we have reached the conclusion, which to

> us seems inescapable, that ice breaking in the St. Lawrence river would create more problems than it would solve." (Excerpts of remarks made at Cleveland, Ohio, May 11, 1971.)

From the foregoing, it becomes clear that there is a most definite conflict between the interests of power and interests of navigation. (Such a conclusion remains justifiable even though PASNY has modified its position somewhat.) It is therefore the purpose of this paper to discuss the legal ramifications that such a conflict does or might hold for the parties.

## BACKGROUND

In order that there might be a more meaningful understanding of the matters under consideration, it is believed that some of the background information might well be helpful.

In the heat of the Seaway controversy, many people have apparently been lead to believe that the improvement of the St. Lawrence River's navigability in the 1950's presented some entirely new questions. Actually, the upper St. Lawrence had been used for navigation for more than a hundred years as a result of improvements accomplished by Canada. Furthermore, at the turn of the century, a 14-foot system was installed by Canada on the lower St. Lawrence.

Turning to the United States' activities, it is noted that as early as 1895 the United States Deep Water Commission was established for the purpose of studying the entire question of a deep water route from the Great Lakes to the Atlantic Ocean. As a result of this Commission's recommendation, a Board of Engineers was appointed to make a definite survey, including the establishment of cost estimates. In 1900 this

Board submitted a report which recommended the improvement of the International Rapids Section of the St. Lawrence River for navigation only, without the development of power.

In 1909 the United States and Canada executed a treaty which, together with the creation of the International Joint Commission (IJC) whose function, in part, it is to exercise jurisdiction over specific matters as they pertain to the boundary waters, reiterated the national policy of both countries that navigation on the effected waters should "...forever continue free and open for the purposes of commerce to the inhabitants, and to the ships, vessels, and boats of both countries equally...". (Art. I, Boundary Waters Treaty of 1909, 36 Stat.(Part 2)2448)

In 1919 Congress expressed the desire for an investigation by the IJC regarding the improvement of the St. Lawrence River between Lake Ontario and Montreal. A Joint Engineering Board was established and a report rendered in 1921, a report now commonly referred to as the Wooten-Bowden Report. (Senate Document No. 179, 67th Cong. 2nd Session.) Some of the principal conclusions and recommendations of this report are as follows:

1. Permanent improvements, with low up-keep cost, for navigation could be installed in that portion of the St. Lawrence River between Montreal and Lake Ontario but these improvements alone were not recommended because of the great loss which would result from the failure to develop potential hydroelectric power within the reach.

2. A total development of this vast quantity of power, however, was not justified because of a lack of market and it was therefore recommended that only a part of the power potential be developed at that time.

3. A sound method of procedure would be the development of the International Rapids Section for navigation and power, providing for a 25-foot navigation channel with 30-foot depths over the lock sills; and the development of the other sections for navigation only, postponing the development of power to a future time as the need arose.

The Wooten-Bowden Report further contemplated construction of power houses at a dam across the river at the downstream end of Long Sault Island, with a control dam located in the vicinity of Ogden Island to regulate the outflow from Lake Ontario and to provide satisfactory navigation between the control dam and Chimney Point.

Subsequently, in 1921, the IJC held public hearings on the subject of the improvement of the International Section of the St. Lawrence River at which time several alternative plans were presented. That same year the IJC submitted its report which contained the following general recommendations:

1. United States and Canada should enter into an agreement by way of a treaty for the improvement of the St. Lawrence River between Montreal and Lake Ontario based upon the Wooten-Bowden Report; and

2. The new Welland Ship Canal should be embodied in the scheme of the treaty and made a part thereof.

In 1924 the St. Lawrence Commission was established. At the same time, the Joint Board of Engineers, consisting of three members from each country, was created to act with this new Commission to study all phases of the problem. In November of 1926 it submitted its report. While the members of the Joint Board of Engineers could not agree upon a plan for the complete development of the International Rapids Section

of the St. Lawrence River, this report contains much valuable material and has been the basis for all subsequent studies of this project. In this regard, it is interesting to note the preferential treatment afforded navigation in the wording of paragraph 109 of the report wherein the basic guidelines were set forth:

> "109. Fundamental Principles. The plans have been prepared in accordance with the recognized principle that the interests of navigation on the St. Lawrence are paramount. A full observance of this principle does not interfere with the beneficial use of the flow of the river for power generation. On the contrary, the improvement of the rapid sections of the river for the joint benefit of navigation and power affords, as a rule, much better navigation than could be secured by the improvement now economically justifiable in the interest of navigation alone." (Emphasis added)

Under the heading of "Power", the report goes on to state that:

> "116...The interests of navigation require that the flow down the St. Lawrence be maintained with a high degree of uniformity to permit the maximum use of water for power by fluctuating the hourly flow to meet fluctuating power demand."

While recognizing that the laws[1/] of the United States place the rights of navigation above all other in the use of the navigable waters of the United States, one cannot and should not overlook the desirability, if there is true compatibility, of developing both the navigation and power potential of a waterway. To this end the report treated at some length the advantages of a winter ice cover, resulting in the conclusion that:

> "106.(5) During the winter months of January, February and March, the discharge capacity of the river will be reduced to an amount materially below that possible during open river months. The successful operation of power plants on the river requires the creation and preservation of an ice cover whenever

---

1/ See Chapter 9, 33 U.S.C. 401-466 as indication of Congressional concern for the protection and promotion of the navigable waters of the United States.

it can be secured at reasonable expense. Since the formation of an ice cover depends upon currents of sufficiently low velocities, the proper winter operation of the power plants requires that the discharge be restricted."

The report went on to recommend that in order to create this ice cover, artificial islands in shoal water might be constructed or as an alternative, booms might be employed. It must be remembered, however, that all recommendations are to be read in light of the fundamental principle that navigation on the St. Lawrence is to be preserved and fostered; otherwise, paragraph 109 is meaningless.

The report did, as shown below, discuss very briefly the possibility of year-round navigation. The following is this discussion in total:

> "150. Alternative Plans Considered. Of the various alternative plans for the improvement of the International Rapids Section submitted to the International Joint Commission in 1921, the one requiring especial consideration at this time is that for navigation and power development proposed by the Hydro-Electric Commission of Ontario and designated as Scheme 'B'. This provided for a two-stage development broadly on the same lines as those proposed by the Canadian Section herein, except that the lower pool was to be held at elevation 210, or 14 feet below the elevation proposed in this report. At this low elevation a large amount of excavation would be required to secure suitable channels for navigation through the lower pool; and an enlargement to secure the low velocities regarded as necessary for satisfactory ice-covered winter operation would be excessively costly, and was not contemplated by the proponents. On the other hand, the higher head at the Ogden Island power plants, amounting to about 30 feet, reduced materially the cost per horse-power of development of the upper head.
>
> "151. The operation of this scheme was based on maintaining an open channel through the river during the winter, and only such channel enlargements were proposed as would be necessary for navigation. (Emphasis added)
>
> "152. The cost, on estimates paralleling those herein presented for a single-stage and two-stage development, would be $254,000,000.
>
> "153. The studies of the Board, and its investigations of power plants operating under similar climatic conditions, show conclusively that it is neither feasible

nor desirable to maintain an open channel through this section in winter when it is improved for power. Even with the present current velocities the ice has at various times caught across the river in the quieter reaches of the section, starting an ice pack which quickly attained large proportions and raised the river level by as much as 10 feet. The likelihood of the ice catching to form ice jams would be increased after the river has been improved, on account of the greatly reduced current velocities. It is certain that an open channel through this 35-mile stretch could not be maintained without ice breakers; and all experience shows that a reasonable number of ice breakers could not be depended upon to keep open continuously so long a channel under these conditions. If, however, an open channel were maintained by such means, the accumulation of ice below the power houses of the lower pool at Barnhart Island would raise the tail-water level at these power houses to such an extent that their output would be greatly curtailed." (Emphasis added)

The reasonable conclusion to be drawn from this discussion is not that navigation lost its place of prominence over power during January, February and March, but rather that the technology of the day precluded the feasibility of maintaining an open channel during this period. Lacking the technical capacity to provide for navigation in January, February and March, it is indeed logical for the drafters to propose methods for the most beneficial use of the waters. Obviously, from the wording of paragraph 153, a completely different conclusion would have been possible and probable had the ice breaking and ice control capability been available.

Although there were intervening reports, the next significant discussion of the problem occurred in 1939 when engineers of the Canadian Department of Transport developed what was called "238-242 Controlled Single Stage Project". In 1940, the Canadian Temporary Great Lakes-St. Lawrence Basin Committee and the United States St. Lawrence Advisory Committee were established and in 1941, they recommended that the "238-242

Controlled Single Stage Project" was "...the best from an engineering and economic point of view bearing in mind the requirements of navigation and power and the protection of the down-river interests."

Following the submission of this report on March 19, 1941, an executive agreement was signed by the governments of the United States and Canada providing for the construction of dams and power works in the International Rapids Section and for the completion of a deep waterway throughout the Great Lakes-St. Lawrence River system. The text of this agreement was then submitted to Congress; however, the bill was not passed.

The Corps of Engineers, acting under a 1940 Executive Order No. 8568, conducted a study on the proposed navigation and hydro power developments in the International Rapids Section. This report in discussing the relative merits and feasibility of the "Controlled Single Stage Project (238-242)" readily recognized the prominency afforded navigation as evidenced by the requirement of the "Project" that the 14-foot navigation channel on the Canadian side of the work site not be interrupted during the construction phase. (Great importance was placed by the Canadian members of the Joint Board of Engineers on this requirement in evaluating construction plans and procedures submitted by the power entities.)

In the ensuing years, further unsuccessful attempts were made to secure the enactment of necessary laws which would authorize the United States' participation in the project. In 1951 Canada announced that it was prepared to undertake the construction of the Seaway as an entirely Canadian project unless the United States was willing to proceed along the lines laid out by the Agreement of 1941. In 1952,

the Governments of the United States and Canada made application to the IJC for permission under the provisions of the Boundary Waters Treaty of 1909 for construction and operation of certain power works as set forth in the "Controlled Single Stage Project 238-242". The Order of Approval was issued by the IJC in 1952.

On July 15, 1953, the Federal Power Commission (FPC), under the provisions of Section 4(e) of the Federal Power Act (33 U.S.C. 791-828) issued a license to the Power Authority of the State of New York for the construction, operation and maintenance of the power facilities in the International Rapids Section of the St. Lawrence River.

Subsequently, the Saint Lawrence Seaway Development Corporation created in 1954, was authorized and directed to construct "...in United States territory deep water navigation works substantially in accordance with the 'Controlled Single Stage Project 238-242'...designated as 'works solely for navigation' in the joint report dated January 3, 1941, of the Canadian Temporary Great Lakes-St. Lawrence Basin Committee and the United States St. Lawrence Advisory Committee, in the International Rapids Section of the St. Lawrence River together with necessary dredging in the Thousand Islands Section...".

In 1956 the IJC supplemented its 1952 Order of Approval, whereunder a new criteria for the maximum mean velocity of the St. Lawrence River and the outflow from Lake Ontario were established.

In 1959 PASNY made application to the St. Lawrence River Joint Board of Engineers, a body created by the IJC, and the Corps of Engineers, for permission, which was subsequently granted, to install ice booms

in the St. Lawrence River. In 1960 PASNY requested permission to install an additional boom which permission was also granted.

The SLSDC has proposed to construct and operate a gate in one of these booms so as to eliminate the impediment the boom presently presents to continuous navigation of the St. Lawrence River. PASNY has been most reluctant to participate or to actively and constructively cooperate in this demonstration project.

DISCUSSION

Having set out a number of the pertinent events leading up to the matter under consideration, a more detailed discussion is now possible.

At this late date it is conclusively held that:

> "The power of the United States over its waters which are capable of use as interstate highways arises from the commerce clause of the Constitution, art. 1, § 8, cl. 3. 'The Congress shall have Power * * * To regulate Commerce * * * among the several States.' It was held early in our history that the power to regulate commerce necessarily included power over navigation. To make its control effective the Congress may keep the 'navigable waters of the United States' open and free and provide by sanctions against any interference with the country's water assets. It may legislate to forbid or license dams in the waters; its power over improvements for navigation in rivers is 'absolute'." (U.S. v. Appalachian Electric Power Co., 311 U.S. 377, at para. 404 and 405, 61 S.Ct. 291, at p. 298 (1940) and citations contained therein.)

In holding that commerce included navigation, the Supreme Court in U.S. v. Chandler-Dunbar Water Power Co., 229 U.S. 53, (1912) quoted with favor from one of its previous decisions:

> "The power to regulate commerce comprehends the control for that purpose, and to the extent necessary, of all the navigable waters of the United States which are accessible from a state other than those in which they lie. For this purpose they are

> the public property of the nation, and subject to all the requisite legislation by Congress. This necessarily includes the power to keep them open and free from any obstructions to their navigation, interposed by the states or otherwise; to remove such obstructions when they exist; and to provide, by such sanctions as they may deem proper, against the occurrence of the evil and for the punishment of offenders. For these purposes, Congress possesses all the powers which existed in the states before the adoption of the national Constitution, and which have always existed in the Parliament in England." (Gilman v. Philadelphia, 3 Wall. 713, 724, 18 L.ed. 96, 99.)

The prominent position held by navigation is clearly manifested by the court in Gibson v. United States, 166 U.S. 269, 41 L. ed. 996, 17 S. CT. 578 when it wrote:

> "All navigable waters are under the control of the United States for the purpose of regulating and improving navigation, and although the title to the shore and submerged soil is in the various states and individual owners under them, it is always subject to the servitude in respect of navigation created in favor of the Federal Government by the Constitution."

The last two cases are cited for the purpose of reflecting the judicial thinking which was present at the time of the drafting of the Boundary Waters Treaty of 1909. There is nothing in this agreement which alters the United States' legislative and judicial concern for the preservation and promotion of navigation but there is, rather, an embodiment of this national concern.

At the outset the contracting parties established the basic principle that navigation on the boundary waters was to remain "...free and open for the purpose of commerce...".

More specifically, Article III of the Treaty provides:

> "...that, in addition to the uses, obstructions, and diversions heretofore permitted or hereafter provided for by special agreement between the Parties hereto, no further

> or other uses or obstructions or diversions, whether temporary or permanent, of boundary waters on either side of the line, affecting the natural level or flow of boundary waters on the other side of the line, shall be made except by authority of the United States or the Dominion of Canada within their respective jurisdictions and with the approval, as hereinafter provided, of a joint commission, to be known as the International Joint Commission."

It was not the intent of this Article to prevent either country from undertaking and/or carrying out government works such as deepening of channels, construction of breakwaters, the improvement of harbors, etc. for the benefit of commerce and navigation provided that these works did not materially affect the level or the flow of the boundary waters nor interfere with the ordinary use of such waters for domestic and sanitary purposes.

Under Article IV of the Treaty, the IJC, except in cases provided for by special agreement, was given the authority to approve the construction or maintenance of any remedial or protective works or dams or other obstructions in the waters flowing from the boundary waters or waters at a lower level than the boundary waters and rivers flowing across the boundary, the effect of such works being to raise the material level of the waters on the other side of the boundary.

Under Article VIII, the Treaty created the IJC and gave it jurisdiction, as previously noted, over all cases involving the use, obstruction or diversion of the waters covered by Articles III and IV.[2/] In carrying out its responsibilities, the IJC was and is to be governed by the following order of precedence in the use of boundary waters:

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2/ It should be remembered that the Treaty specifically provided that the parties may, by special agreement, construct certain facilities which would not require IJC approval.

"(1) Uses for domestic and sanitary purposes;
"(2) Uses for navigation, including the service of canals for the purposes of navigation;
"(3) Uses for power and for irrigation purposes."

Article VIII goes on to state that in a case involving the elevation of the natural level of waters "as a result of the construction or maintenance of remedial or protective works or other obstructions in the boundary waters", the IJC, as a condition of its approval thereof, shall require "suitable and adequate provision...for the protection and indemnity of all interests on the other side of the [boundary] line which may be injured thereby." (It is noted that the treaty further provides for the submission by the Government to the IJC of matters of difference; organizational items; etc. which provisions are not relevant to the subject matter of this paper.)

From the foregoing it seems fairly clear that, in the absence of a special agreement, the IJC has been given the responsibility of regulating, within the guidelines enumerated in the Treaty, the flow and level of boundary waters.

Limitation of time has prevented an extensive review of cases interpreting the provisions of this treaty; however, a 1964 decision, Power Authority of the State of N.Y. v. Federal Power Commission, 339 F.2d 269, Cert. den. 381 U.S. 935, is believed to be indicative of the prevailing judicial treatment. In claiming an exemption from the payment of annual charges levied by the FPC, PASNY alleged "...that the project in which it was engaged was primarily designed to improve navigation, and it also claimed that the power it produced was either used by it for state or municipal purposes or was sold ultimately to the public without profit." In holding against PASNY, the court stated:

"The Power Authority worked only on those portions of the overall St. Lawrence River program that were designated in the 1940 report as being primarily for power, or common to power and navigation, and never on those portions which were designated as solely for navigation. Furthermore, the authorizations granted to the Power Authority by the International Joint Commission, the President of the United States, and the Federal Power Commission refer almost exclusively to the production of hydro-electric power. Even the Power Authority concedes that one-fifth of its construction costs were for works that only benefited power production.

"The Power Authority claims that the authorizations it was granted nevertheless gave primacy to navigational improvements. It points to the fact that the 1909 treaty on the development of boundary waters expressly preferred uses for navigation to uses for power, and that both the International Joint Commission and the Federal Power Commission recognized this preference as binding upon them when they issued their approval orders and provided for the implementation of those orders. But those expressions of navigational preference need only mean that in case of conflict power production must give way to unimpeded navigation. They no more prove that the primary purpose of the project was to facilitate navigation than a provision for a draw on a bridge over the St. Lawrence would prove that the primary purpose of the bridge was to aid navigation.

"The Power Authority also contends that most of the major features of the project aid navigation as well as aid in the production of power; that they would have been designed differently, and less expensively, were it not for the aim of promoting navigation; and that these features have at times been operated contrary to the interest of power production in order to advantage navigation. Assuming that all these contentions are true, again they need prove no more than that ease of shipping is an important secondary value of the project and at times should be given the right of way. The Commission was not required to regard these contentions as conclusive of the fact that the project was designed primarily for navigation."

Recognizing that construction of the power works in the International Section would indeed affect the flow of the St. Lawrence River and the

level of Lake Ontario, the United States Government made an application, as did the Canadian Government, to the IJC requesting approval for the construction and operation of such works. The works, as has been previously indicated, were those designated within the plan known as "Controlled Single Stage Project (238-242)" and, as provided in Article 10 of the application, were to be designed, constructed, operated and maintained in accordance with the following conditions:

> "a. All main features of the project described herein shall be so planned, located, constructed, and operated as to be adaptable to the improvement of the International Rapids Section of the St. Lawrence River for navigation purposes, to the aid and benefit of commerce and navigation, and to the preservation of the rights and interests of the United States and Canada in the waters of the International Rapids Section of the St. Lawrence River under the Boundary Waters Treaty of 1909. The works shall be operated and maintained in conformity with the requirements of the prior rights and interests of navigation on the St. Lawrence River and in such a manner as to protect the rights and interests of others engaged in the development of power in the river below the International Rapids Section. The maintenance and operation of the works on the United States side of the International Boundary shall be subject to the supervision of the United States. [Emphasis added]

* * * * *

> "d. A 'Board of Control' (referred to hereinafter as the Board) consisting of an equal number of representatives of the United States and Canada shall be established by the International Joint Commission. The duties of the Board shall be to ensure compliance with the conditions in regard to the regulation of the discharge from Lake Ontario and the flow through the International Rapids Section as set forth hereinbefore, and to carry out such other duties as may be delegated to it by the International Joint Commission."

* * * * *

From the above quoted conditions, it is abundantly clear that the power works were intended to be designed, planned, located, constructed

and operated so as to facilitate the improvement of the river for navigation. Furthermore, the power facilities were to be an aid and benefit to commerce and navigation. It was apparently contemplated that the power entity would have the responsibility of undertaking an active, not passive or obstructionary, role in the furtherance of the interest of navigation. Finally, there can be little question that it was the position of the United States Government that navigation had "...prior rights and interests..." on the St. Lawrence River and that the power works must be operated and maintained in conformity with those requirements. A reading of the Canadian application reflects total concurrence with the United States' position.

In approving the United States application, the Order of Approval issued in 1952 authorized construction of the power works subject to certain conditions, namely:

> "(a) All interests on either side of the international boundary which are injured by reason of the construction, maintenance, and operation of the works shall be given suitable and adequate protection and indemnity in accordance with the laws in Canada or the Constitution and laws in the United States, respectively, and in accordance with the requirements of Article VIII of the treaty.
>
> "(b) The works shall be so planned, located, constructed, maintained, and operated as not to conflict with or restrain uses of the waters of the St. Lawrence River for purposes given preference over uses of water for power purposes by the treaty, namely, uses for domestic and sanitary purposes and uses for navigation, including the service of canals for the purposes of navigation, and shall be so planned, located, constructed, maintained, and operated as to give effect to the provisions of this order. [Emphasis added]
>
> "(c) The works shall be constructed, maintained, and operated in such manner as to safeguard the rights and lawful interests of others engaged or to be engaged in the development of power in the St. Lawrence River below the International Rapids section.

"(d) The works shall be so designed, constructed, maintained, and operated as to safeguard so far as possible the rights of all interests affected by the levels of the St. Lawrence River upstream from the Iroquois regulatory structure and by the levels of Lake Ontario and the lower Niagara River; and any change in levels resulting from the works which injuriously affects such rights shall be subject to the requirements of paragraph (a) relating to protection and indemnification."

* * * * *

While not employing the verbatim language in the Order of Approval that was contained in Article 10 of the United States application, the clear intention to afford to navigation superior rights regarding the use of the waters of the St. Lawrence River is contained in the above-quoted paragraph (b).

In addition to establishing the velocity of the St. Lawrence River and the outflow and levels of Lake Ontario, the Order created the International St. Lawrence River Board of Control and made reference to "...the establishment by the Governments of Canada and of the United States of a Joint Board of Engineers to be known as the St. Lawrence River Joint Board of Engineers..."[3/] It was the responsibility of the Joint Board of Engineers to review, coordinate and, if both governments so authorized, approve the plans and specifications of the works and programs for construction. The Board of Control had the responsibility, upon the completion of the works, to insure that the provision of the approval Order "...relating to water levels,

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3/ It should be noted that the Board of Control was created by the IJC and therefore a Board directly responsible to the IJC and in fact, an arm of the IJC. The Joint Board of Engineers was not so established for it found its' birthright in the application of the two governments and did not act in behalf of the IJC but were rather the agents of their respective governments. Furthermore, membership to the U.S. portion of the Joint Board was accomplished by Presidential order.

the regulation and the discharge of water from Lake Ontario and the flow of water through the International Rapids section...will be complied with." In carrying out its responsibilities under the Order, the Joint Board of Engineers issued a statement regarding their duties and operation. Therein, the Board wrote that in accomplishing their task "...the dominant considerations..." were to:

> "a. Assure that the design and construction of the power works make adequate provisions for the needs of present and future navigation on the International Rapids Section, St. Lawrence River, and above and below.
>
> "b. Assure that the works shall be so designed and constructed as to safeguard the rights of all interests of others engaged, or to be engaged, in the development of power in the St. Lawrence River below the International Rapids Section.
>
> "c. Assure that the works shall be so designed and constructed as to safeguard so far as possible the rights of all interests affected by the levels of the St. Lawrence River upstream from the Iroquois regulatory structure and by levels of Lake Ontario and the lower Niagara River; likewise to assure that adequate provision is made for the discharge and stages of water in the International Rapids Section during construction.
>
> "d. Assure that safety and adequate provisions against maloperation are inherent in all structural elements including embankments during construction."

Again, the prominent position of navigation is not only recognized but positive procedures were developed to assure the preservation of this position.

Before leaving the Order of Approval, it should be noted that the IJC's approval did not authorize the construction of navigation works nor did either Government request permission from the IJC. This particular subject was discussed at hearings before the Senate's Subcommittee of

the Committee on Foreign Relations when that body was considering S. 589 which subsequently became Public Law 358. The following transpired between Senator Humphrey and Mr. N. R. Danielian, Executive Vice President of the Great Lakes-St. Lawrence Association:

> "SENATOR HUMPHREY. Mr. Danielian, you are an expert in this field, you studied the law. Do you see any legal complications involved in the Wiley bill? Let me restate that by asking you this: Do you find within existing treaties ample authority for the basic legislation that is proposed in the Wiley bill?
>
> "MR. DANIELIAN. Under the Wiley bill this is no different from all the other canals that we have been building in American territory, because the whole work is in American territory.
>
> "SENATOR HUMPHREY. Under the Wiley bill?
>
> "MR. DANIELIAN. That is right.
>
> "SENATOR HUMPHREY. However, the waterway, the waters of the St. Lawrence River are governed by the treaty?
>
> "MR. DANIELIAN. Yes, to the extent that any work affects the level of the lakes they would be governed by the Boundary Waters Treaty of 1909. There is nothing in the construction of this canal that would affect the level of the lakes.
>
> "SENATOR HUMPHREY. So you feel, sir, that there is no constitutional question involved, there is no international question involved, that may precipitate us into a court or in the process of adjudication?
>
> "MR. DANIELIAN. I do not want to pose as a constitutional authority here, but none has come to my attention.
>
> "SENATOR HUMPHREY. Well, believe me, if it has not come to your attention there must not be any."

* * * * *

(Hearings before the Subcommittee of the Committee on Foreign Relations, United States Senate, 83rd Cong., 1st Session, on S. 589 and amendments thereto, S. 1065, and S.J. Res. 45, Bills and Joint Resolution relating to the St. Lawrence Seaway and Power Project; and for other purposes, April 14, 15, 16, May 20 and 21, 1953.)

As was contemplated by the Boundary Waters Treaty, the governments of Canada and the United States exchanged diplomatic notes on August 17, 1954, the result of which was an international agreement relative to the construction of the Montreal to Lake Erie section of the St. Lawrence Seaway.

Turning now to licensing of the project under Section 4(e) of the Federal Power Act. As early as the Rivers and Harbors Act of 1899, it was unlawful to construct a dam in any navigable waters of the United States without the consent of Congress. (33 U.S.C. 401 and 403) By the Federal Water Power Act of 1920 (41 Stat. 1063)[4/] however, Congress created a Federal Power Commission with authority to license the construction of such dams and other works upon specified conditions. Over the years the jurisdiction and powers of the Commission have been challenged on many occasions with the courts continually holding:

> "That Congress has the power to legislate where commerce between the states or with foreign countries may be affected is no longer an open question. And such power is not restricted to 'an adverse effect upon the present and existing navigable capacity of federal waters'; it extends to navigable capacity after reasonable improvements which might be made, and whether the effect is beneficial or injurious. The Federal Power Act was intended to develop, conserve, and utilize the navigation and water power resources of the country, and to that end requires that projects licensed shall 'be best adapted to a comprehensive plan for improving or developing a waterway or waterways for the use or benefit of interstate or foreign commerce,' hence, 'if upon investigation [the Commission] shall find that the interests of interstate or foreign commerce would be affected,' it may require a license." (Georgia Power Co. v. Federal Power Commission, 152 F.2d 908, at 913 (1946)

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4/ This Act was amended by 49 Stat. 939 (1935) U.S.C. Supp. V, Title 16, §791a et seq, 16 U.S.C. §791a et seq by which it became known as the Federal Power Act.

The Congressional licensing philosophy being clearly indicated by the above quote, a review of the license issued to PASNY reflects that it was for a term of 50 years and it authorized PASNY, as the Presidentially-designated United States agency, to construct, operate and maintain the power facilities in the International Section of the St. Lawrence River and distribute commercially the power generated therefrom subject to certain terms and conditions: (Only those terms and conditions relating to navigation have been set out.)

> "Article 7. So far as is consistent with proper operation of the project, the Licensee shall allow the public free access, to a reasonable extent, to project waters and adjacent lands owned by the Licensee for the purpose of full public utilization of such lands and waters for navigation and recreational purposes, including fishing and hunting, and shall allow for such purposes the construction of access roads, wharves, landings, and other facilities on its lands the occupancy of which may in appropriate circumstances be subject to payment of rent to the Licensee in a reasonable amount: Provided, that the Licensee may reserve from public access such portions of the project waters, adjacent lands, and project facilities as may be necessary for the protection of life, health, and property and, Provided further, that the Licensee's consent to the construction of access roads, wharves, landings, and other facilities shall not without its express agreement place upon the Licensee any obligation to construct or maintain such facilities.
>
> "Article 8. Insofar as any material is dredged or excavated in the prosecution of any work authorized under the license, or in the maintenance of the project, such material shall be removed and deposited so it will not interfere with navigation, and will be to the satisfaction of the District Engineer, Department of the Army, in charge of the locality.
>
> * * * * *
>
> "Article 10. Whenever the United States shall desire to construct, complete, or improve navigation facilities in connection with the project, the Licensee shall convey to

the United States, free of cost, such of its lands and its rights-of-way and such right of passage through its dams or other structures, and permit such control of pools as may be required to complete and maintain such navigation facilities.

*     *     *     *     *

"Article 12. The operation of any navigation facilities which may be constructed as a part of or in connection with any dam or diversion structure constituting a part of the project works shall at all times be controlled by such reasonable rules and regulations in the interest of navigation, including the control of the level of the pool caused by such dam or diversion structure, as may be made from time to time by the Secretary of the Army. Such rules and regulations may include the construction, maintenance, and operation by the Licensee, at its own expense, of such lights and signals as may be directed by the Secretary of the Army.

"Article 13. The United States specifically retains and safeguards the right to use water in such amount, to be determined by the Secretary of the Army, as may be necessary for the purposes of navigation on the navigable waterway affected; and the operations of the Licensee so far as they affect the use, storage, and discharge from storage of waters affected by the license, shall at all times be controlled by such reasonable rules and regulations as the Secretary of the Army may prescribe in the interest of navigation, and as the commission may prescribe for the protection of life, health, and property, and in the interest of the fullest practicable conservation and utilization of such waters for power purposes and for other beneficial public uses, including recreational purposes; and the Licensee shall release water from the project reservoir at such rate in cubic feet per second, or such volume in acre-feet per specified period of time, as the Secretary of the Army may prescribe in the interest of navigation, or as the Commission may prescribe for the other purposes hereinbefore mentioned.

*     *     *     *     *

"Article 19. In the design, construction, maintenance and operation of the project covered by this license, the Licensee shall comply with all applicable provisions and requirements of the Order of Approval (International Joint Commission Docket 68) issued October 29, 1952, by the International Joint Commission to the Governments of the United States and Canada for the construction of certain works for the development of power in the International Rapids Section of the St. Lawrence River.

*     *     *     *     *

This brings us to the installation of the ice booms. As a result of a rather severe ice jam in the latter part of the '50s, PASNY explored means for the control of the river ice. As has been indicated above, they would have to look no further than the 1926 report for a suggested solution to the problem. PASNY submitted their proposal for the use of ice booms to both the Corps of Engineers and the St. Lawrence River Joint Board of Engineers. In its application to the Corps of Engineers, PASNY noted that the boom located west of Ogdensburg would "...not be placed across deep draft navigation channel prior to close of navigation each year. Ice boom across deep draft channel including cables and anchors to be removed prior to opening of navigation each year. Also shore terminal of ice boom to be placed and removed each year upon the close and opening of navigation in a manner so that there is no interference with the movement of vessels." In the permit issued by the Department of the Army, PASNY was authorized by the Secretary of the Army "...to place an ice boom during the non-navigation season...in the United States waters of the St. Lawrence River between Ogdensburg, New York and Prescott, Ontario, vicinity of Chimney Point, Ogdensburg, New York; the upstream end of Butternut Island, and from the United States mainland to Galop Island." The installation of such booms were, however, subject to the following conditions:

*     *     *     *     *

"(c) That there shall be no unreasonable interference with navigation by the work herein authorized.

"(d) That if inspections or any other operations by the United States are necessary in the interest of navigation, all expenses connected therewith shall be borne by the permittee.

* * * * *

> "(f) That if future operations by the United States require an alteration in the position of the structure or work herein authorized, or if, in the opinion of the Secretary of the Army, it shall cause unreasonable obstruction to the free navigation of said water, the owner will be required upon due notice from the Secretary of the Army, to remove or alter the structural work or obstructions caused thereby without expense to the United States, so as to render navigation reasonably free, easy, and unobstructed; and if, upon the expiration or revocation of this permit, the structure, fill excavation, or other modification of the watercourse hereby authorized shall not be completed, the owners shall, without expense to the United States, and to such extent and in such time and manner as the Secretary of the Army may require, remove all or any portion of the uncompleted structure or fill and restore to its former condition the navigable capacity of the watercourse. No claim shall be made against the United States on account of any such removal or alteration.
>
> "(g) That the United States shall in no case be liable for any damage or injury to the structure or work herein authorized which may be caused by or result from future operations undertaken by the Government for the conservation or improvement of navigation, or for other purposes, and no claim or right to compensation shall accrue from any such damage."

In authorizing the boom installation, after soliciting comments from the Board of Control which were to the effect that the boom "...would not affect the water levels and [lake] discharges materially", the St. Lawrence River Joint Board of Engineers stated that their approval was being given "[w]ith the understanding that during the navigation season booms and boom cables will be removed and anchor cables dropped to the bottom, all anchors except those within 600 feet on each side of the center line of the navigation channel shall be buoyed." The Board of Engineers further commented that "[t]he placement and removal of ice booms shall be timed so as not to interfere with the requirements of navigation and the St. Lawrence Seaway Authority and the Saint Lawrence Seaway Development Corporation shall be kept informed of all such operations."

While both authorizations were and are very explicit regarding non-interference with navigation, the Corps of Engineers' permit went even further by placing the responsibility upon PASNY that in the event the booms cause "an unreasonable obstacle" to navigation, they will be removed or altered as the situation may require.

At the request of the IJC, the United States, on August 5, 1974, concurred in the assumption of jurisdiction by the IJC over these booms. In so doing, the government stated:

> "The United States Government has carefully examined the implications of the Commission's request for the assumption of jurisdiction and is of the opinion that the Commission has the authority to exercise such jurisdiction. The United States Government wishes to note, however, that in the exercise of jurisdiction the Commission is subject to the order of precedence established by the Boundary Waters Treaty of 1909 and that: (a) such jurisdiction is subject to the express reservations contained in the United States Application to the Commission of June 30, 1952 and in particular, Sections 12, 13 and 14 of that Application, (b) the approval of assumption of jurisdiction over the international aspects of the subject ice booms does not abrogate or supersede the authority of the Secretary of the Army to prevent the obstruction of the navigable waters of the United States under 33 USC 403. The ice booms and their operation shall remain subject to the Department of the Army permits authorizing their placement. (c) Further, in accordance with your letter of January 28, the United States will regard the approvals of the International St. Lawrence Joint Board of Engineers on August 4, 1960 as an approval given by the Commission."

Of late PASNY has expressed concern "that interests other than power should be prepared to accept legal responsibility for adverse affects on private and public property if...[the installation of a gate in the ice boom] designed to extend the navigation season are undertaken." Additionally, PASNY has asked who will be responsible in the event their power production is reduced as a result of the Winter Navigation Program.

It is assumed that PASNY is speaking of the Federal Government in making reference to "interests other than power" for the Winter Navigation Program is a Federal activity. The question then becomes one of what is the Federal Government's legal responsibility for "adverse effects on private and public property and for the reduction of power products"?

As presented, this is indeed a many-faceted problem. Regarding riparian owners rights, a review of appropriate United States law discloses that all the states bordering on the Great Lakes and the St. Lawrence recognize the same general rules of law. The major feature of riparian doctrine is that it gives the owners of land bordering upon a stream equal rights to the use of the water. In modern times the rule is often stated that each riparian may make a reasonable use of the water consistent with like uses by the others.

But whatever these riparian rights may be, the important fact about them is that the Supreme Court has consistently held that they are subject to the right of the Federal government to regulate navigation under the Commerce Clause of the Constitution. The Federal government is not obligated to pay for any damage or destruction to riparian rights in navigable waters as the result of the regulation of commerce. This power of the Federal government is referred to as the navigational servitude and the Supreme Court has defined it as "the privilege to appropriate without compensation which attaches to the exercise of the power of the government to control and regulate navigable waters in the interest of commerce". (U.S. v. Va. Electric and Power Co., 365 U.S. 624, 62728 (1961).)

Even someone who owns land under navigable water cannot use that land in any manner repugnant to the government's paramount right to regulate navigation and the government may construct bridges, locks or other navigation structures on that underwater land without compensating its owner for its use. (Gibson v. U.S., 166 U.S. 269, 272 (1897).)

Besides the rights of riparian landowners, the general public has the right to use navigable waters, particularly for navigation and, in some cases, for fishing and recreation. But, these public rights are also completely subject to the right of the Federal government to regulate navigation and commerce. Thus, no one can claim any legal right to compensation if his "right" to use navigable waters or ice is interfered with in any way by the season extension project. (I. Farnham, The Law of Waters, 130-31 (1904).)

But, saying that no compensation can be claimed for water rights does not mean that no private claims of any sort can be asserted against the Federal Government if the demonstration project is undertaken. On the contrary, there are two major claims that, under U.S. laws, could be successfully asserted by private individuals against the government. The first is the right of the owners of fast land above the high water line to receive compensation if the project directly interferes with their use or occupancy of their land. The other is the right that everyone has to receive compensation if they or their property are damaged by some negligent act of the Government.

In response to the question raised by PASNY as to who, other than PASNY, will be responsible for loss of power, we are again directed

back to that well settled concept that in the navigable waters of the United States, the Federal Government's authority is absolute.

In order for PASNY to recover for the loss of power production resulting from a reduction of water capacity, there must exist in PASNY some private right to the waters of the St. Lawrence River which right has either been damaged or taken as a result of the Winter Navigation Program. As has been seen, the Federal Government's "...power flows from the grant to regulate, i.e. to 'prescribe the rule by which commerce is to be governed.' This includes the protection of navigable waters in capacity as well as use. This power of Congress to regulate commerce is so unfettered that its judgment as to whether a structure is or is not a hindrance is conclusive. Its determination is legislative in character. The Federal Government has domination over the water power inherent in the flowing stream. It is liable to no one for its use or non-use. The flow of a navigable stream is in no sense private property; 'that the running water in a great navigable stream is capable of private ownership is inconceivable.'" (U. S. v. Appalachian Electric Power Co., supra., U. S. v. Chandler-Dunbar Co., supra.)

Furthermore, PASNY's license and the laws[5] under which it was issued contemplate the use of the navigable waters of the St. Lawrence

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5/ An early discussion of the Federal Water Power Act of 1920 is contained in Alabama Power Co. v. Gulf Power Co., 283 F. 606 (1922). There the court wrote:

> "Section 6 is that:
>
> 'Each such license shall be conditioned upon acceptance by the licensee of all the terms and conditions of this Act and such further conditions, if any, as the Commission shall prescribe in conformity with this Act, which said terms and conditions and the acceptance thereof shall be expressed in said license.'

for power at the sufferance of Congress. Therefore, there can be no complaint or claim by PASNY, for in order to gain the right to produce power for commercial consumption it accepted the Congressionally-imposed determination that the preservation and improvement of navigation was in the public interest. (Portland General Electric Co. v. Federal Power Commission, 328 F.2d 165 (1964).)

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"Thus the matter of license to construct the dam becomes in its nature the contract between the licensee and the government for making the improvement, and when accepted the licensee is bound to comply with its conditions or submit to forfeiture of license.

"Section 10 goes more into detail, for it provides:

'That all licenses issued under this Act shall be on the following conditions:

(2) That the project adopted, including the maps, plans, and specifications, shall be such as in the judgment of the commission will be best adapted to a comprehensive scheme of improvement and utilization for the purposes of navigation, of water-power development, and of other beneficial public uses; and if necessary in order to secure such scheme* * *'--that is, a scheme in the interest of navigation, which is the paramount consideration--' the commission shall have authority to require the modification of any project, * * *'--and 'project' includes navigation structures--' 'and of the plans and specifications of the project works before approval.'

"Further:

'(c) That the licensee shall maintain the project works in a condition of repair adequate for the purposes of navigation and for the efficient operation of said works in the development and transmission of power, shall make all necessary renewals and replacements, shall establish and maintain and operate said works so as not to impair navigation, and shall conform to such rules and regulations as the Commission may from time to time prescribe for the protection of life, health, and property.'

## CONCLUSIONS

While there are many detailed conclusions that can be drawn from the foregoing discussion, it is indeed most reasonable to generally conclude the following:

1. It is the national policy of the United States that the navigation of the waters of the United States is to be preserved and fostered.

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Section 11 stipulates 'that if the dam or other project works are to be constructed across, along, or in any of the navigable waters of the United States, the commission * * *' will require certain things, of which I will give the ones with reference to navigation. The Act states:

"That such licensee shall, to the extent necessary to preserve and improve navigation facilities, construct, in whole or in part, without expense to the United States, in connection with such dam, a lock or locks, booms, sluices, or other structures for navigation purposes, in accordance with plans and specifications approved by the Chief of Engineers and the Secretary of War and made part of such license.'

In other words, as a fundamental requirement of the acceptance of the license, the licensee is bound to do these things in reference to navigation. Further it is required:

'(b) That in case such structures for navigation purposes are not made a part of the original construction at the expense of the licensee then whenever the United States shall desire to complete such navigation facilities the licensee shall convey to the United States, free of cost, such of its land and its rights of way * * * through its dams, * * * and permit such control of pools as may be required to complete such navigation facilities.

'(c) That such licensee shall furnish free of cost to the United States power for the operation of such navigation facilities, whether constructed by the licensee or by the United States.'

It would seem that section 11 is sufficient to show that the paramount object of the act is the promotion of navigation."

2. Congress has absolute authority over the navigable waters of the United States and can and does regulate their use in furtherance of the national policy stated in subparagraph 1 above.

3. As long as other uses, i.e. power production, are truly compatible so as not to conflict with or restrain present and/or future use of these waters for navigation, such uses are authorized. To this end, the Federal Power Act was enacted.

4. The Boundary Waters Treaty of 1909 embodies the national policy regarding the use of the navigable waters of the United States and places within the IJC, absence a special agreement between the governments, the responsibility for the control of the levels and flows of the boundary waters. In the application of this power, the IJC is governed by the principle that "...in the case of conflict, power production must give way to unimpeded navigation." A reading of the United States application to the IJC for permission to construct, operate and maintain the power works, the Order of Approval, FPC license, Corps' permit for the installation of the ice boom, and PASNY's own interpretation of the pertinent documents, makes it abundantly clear that such facilities and related activity must not, actively or passively, interfere with the superior rights of navigation.

5. There being no private right in the water producing capacity of the St. Lawrence River, PASNY would have no claim against the Corporation/United States for loss of power generation in the event such resulted from the use of the waters for navigation. PASNY should not now be allowed to complain, for in return for the opportunity to produce power for profit PASNY accepted this condition and must now be willing to abide by the terms of its bargain.

6. In the absence of damages to riparian owners resulting from negligent acts of employees of the United States or the taking of riparian land by the United States, there is no liability on the part of the United States for the use of the waters of the St. Lawrence River for navigational purposes.

7. Finally, the legal right to produce power from the waters of a navigable stream is secondary to the predominant legal right to use that same water for navigation; therefore the power entities should not be allowed to impede the use of or the future development of any waterway for navigational purposes.

Frederick A. Bush
General Counsel

Saint Lawrence Seaway Development Corporation

April 4, 1975

# APPENDIX K

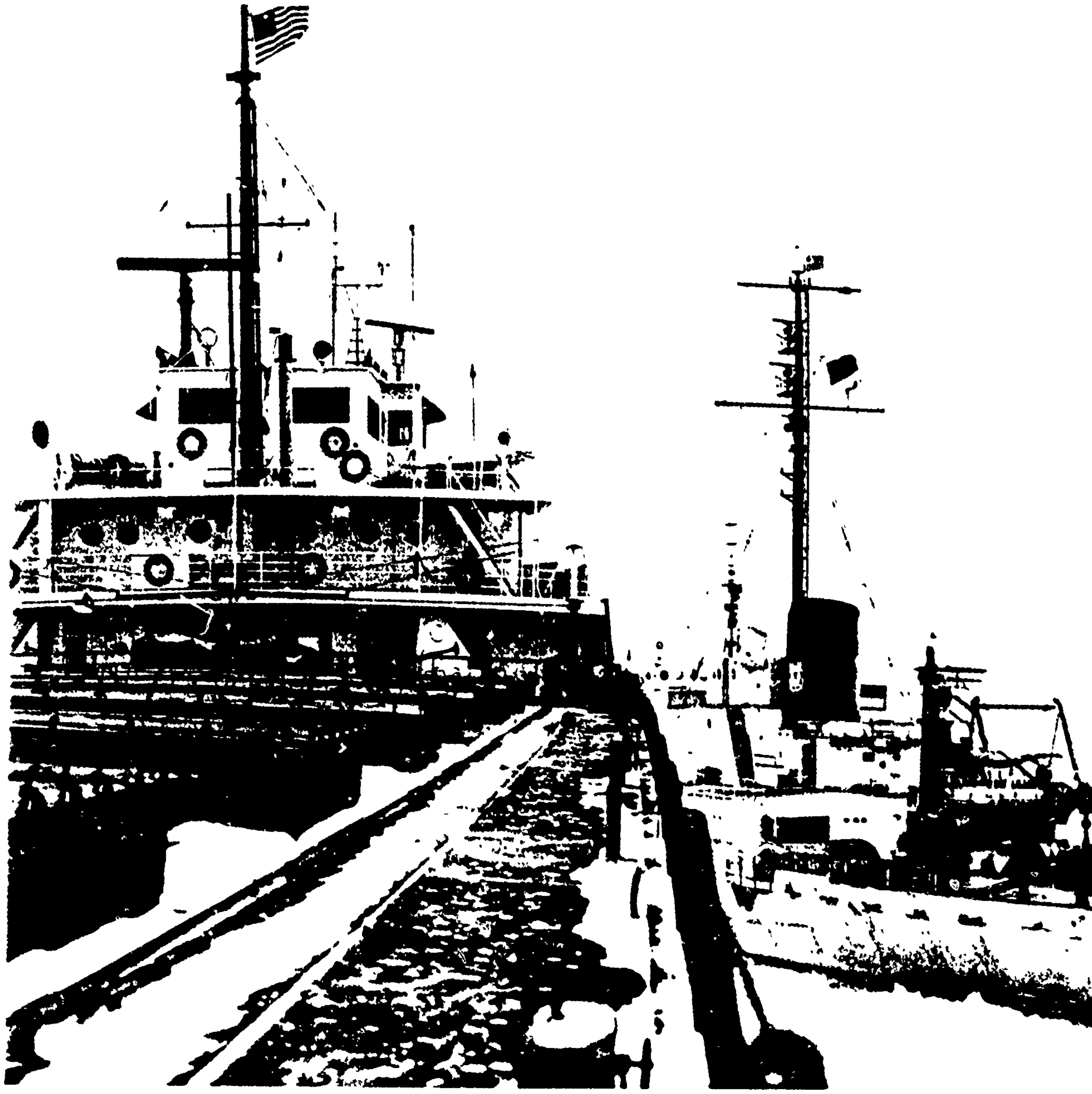
DEMONSTRATION
PROGRAM REPORT

AUGUST 1979

APPENDIX K

DEMONSTRATION PROGRAM FINAL REPORT

This Appendix contains the Demonstration Program Final Report.



# DEMONSTRATION PROGRAM FINAL REPORT

GREAT LAKES AND ST. LAWRENCE SEAWAY

WINTER NAVIGATION BOARD

September 1979

## GREAT LAKES AND ST. LAWRENCE SEAWAY
## WINTER NAVIGATION BOARD

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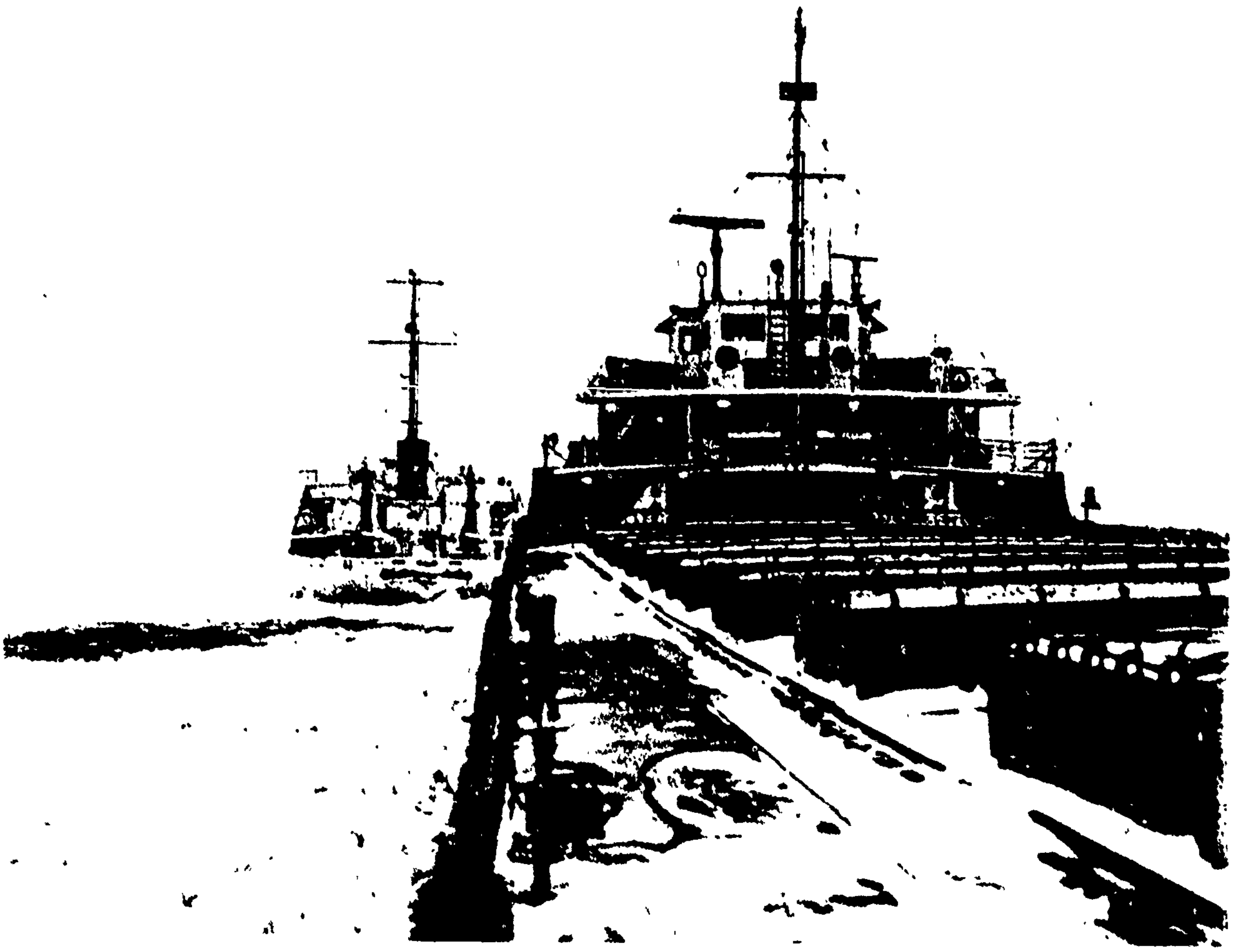
GREAT LAKES AND ST. LAWRENCE SEAWAY
NAVIGATION SEASON EXTENSION DEMONSTRATION PROGRAM



The Great Lakes and St. Lawrence Seaway Winter Navigation Board

# Demonstration Program Final Report

September 1979

## WINTER NAVIGATION BOARD

*Voting Members*

*Participating Agencies*

UNITED STATES ARMY CORPS OF ENGINEERS (CHAIRMAN)
UNITED STATES COAST GUARD (VICE-CHAIRMAN)
ST. LAWRENCE SEAWAY DEVELOPMENT CORPORATION
MARITIME ADMINISTRATION
FEDERAL ENERGY REGULATORY COMMISSION
U.S. DEPARTMENT OF THE INTERIOR
GREAT LAKES BASIN COMMISSION
GREAT LAKES COMMISSION
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
ENVIRONMENTAL PROTECTION AGENCY
GREAT LAKES STATES REPRESENTATIVE

*Private Interest Advisory Group*

LAKE MARINE ENGINEERS BENEFICIAL ASSOCIATION
GREAT LAKES TASK FORCE

*Observers*

ST. LAWRENCE SEAWAY AUTHORITY OF CANADA
CANADIAN COAST GUARD
INTERNATIONAL JOINT COMMISSION
U.S. DEPARTMENT OF STATE

*Technical Advisors*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

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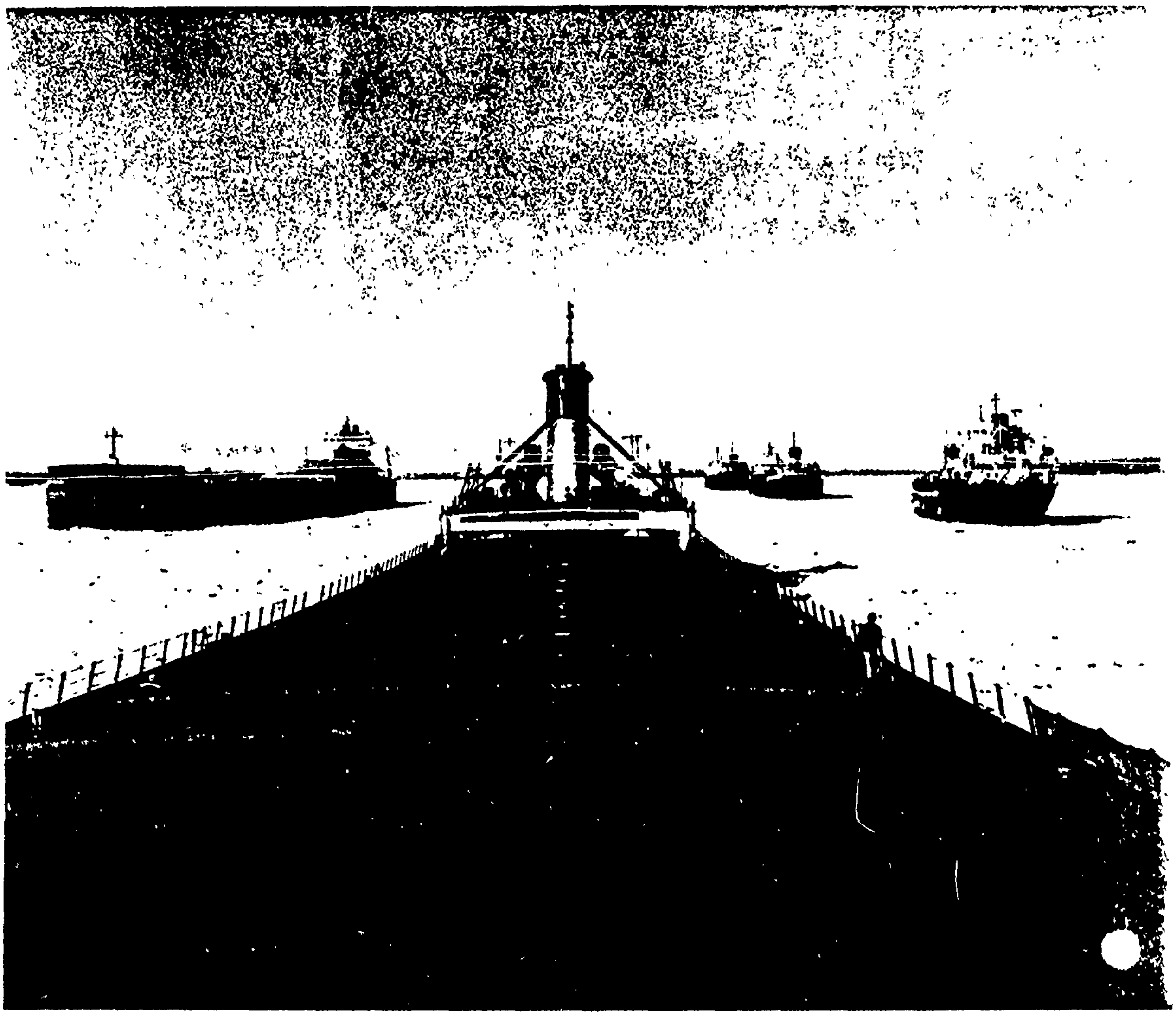
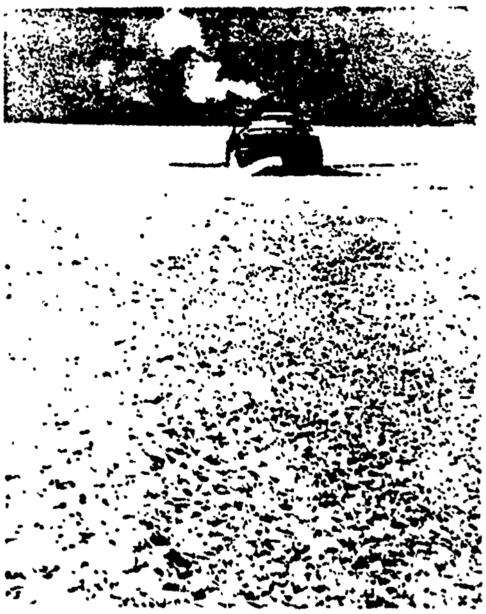


*Convoy in ice.*

# PREFACE

*Vessel moves through ice field.*



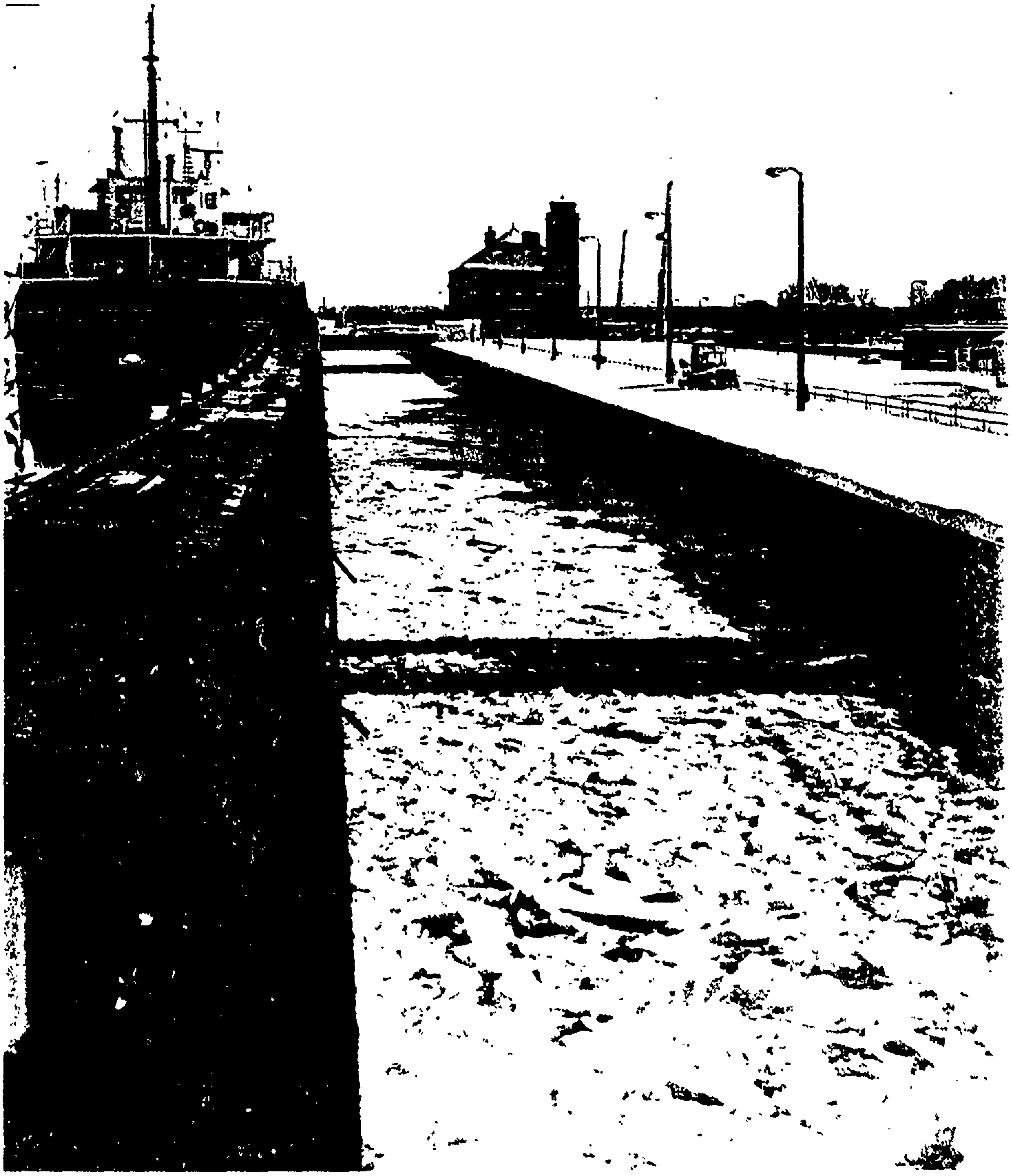
The Great Lakes and St. Lawrence Seaway Navigation Season Extension Demonstration Program is authorized by Congress in the River and Harbor Act of 1970 (Public Law 91-611), amended by the Water Resources Development Acts of 1974 and 1976 (Public Laws 93-251 and 94-587, respectively). This program was undertaken to demonstrate the practicability of extending the navigation season on the Great Lakes and St. Lawrence Seaway System. It is important to note that while the program and study are in response to specific legislation by Congress, participating Federal agencies have continuing responsibilities for development of ice control measures; these are funded and carried out under normal mission activities, funded under individual agency programs. These programs are discussed in this report, but not distinguished from Demonstration Program activities. Costs of normal mission activities are not included in specifically authorized program funding.

At the onset of the program, preliminary conclusions existed which indicated that engineeringly feasible measures were already available to extend the navigation season. In authorizing the program, Congress provided a means to verify these conclusions and to demonstrate the practicability of extending the navigation season.

This and previous reports on the Demonstration Program confirm that many of the originally stated conclusions are correct: Technical measures presently exist which are effective in extending the traditional navigation season and they involve varied economic, social and environmental impacts. They are discussed in this report.

This report is the last in a series dealing with demonstration activities undertaken or studied to facilitate commercial vessel operation on the Great Lakes and St. Lawrence Seaway. Activities conducted during the first five years of the program were described in some detail in the Winter Navigation Board's previously published reports. This report summarizes the activities, results, and conclusions reached during the eight years of the Demonstration Program.

The results of the demonstration activities are a primary data source for and are supportive of the Survey Study currently being conducted by the U.S. Army Corps of Engineers. The Survey Study is to identify the costs, economic benefits, engineering feasibility, and the social and environmental acceptability of extending the navigation season. The Report is provided at the direction of Congress to assist in determining the Federal interest in a permanent navigation season extension on the Great Lakes and St. Lawrence Seaway System.



*Looking toward Soo Locks.*

# THE WINTER NAVIGATION BOARD SUMMARY REPORT

Fiscal Year 1979 was the final year of a program to demonstrate the practicability of various means of extending the navigation season on the Great Lakes-St. Lawrence Seaway System, This executive summary abstracts the most important aspects from the full report on program activities and achievements accomplished under the Demonstration Program.

## Part I: Background and Perspective

*The need*

The Great Lakes-St. Lawrence Seaway System is a deep draft waterway which provides a means of energy efficient, low cost marine transportation to the U.S. heartland -- a 19-state economic hinterland area which generates some 41% of the nation's personal income.

Agriculture, mining, petroleum refining, and the manufacture of both durable and non-durable goods are important industries within the area. The need for the movement of both bulk raw materials and finished products is substantial.

Historically, however, in mid-December, the waterborne link of the regional transportation system has closed down for up to four months due to weather and ice conditions ... remaining closed until early April, when conditions again permitted transit, without assistance.

Industry in the region relying on bulk materials has adapted to the closed season by stockpiling, a costly process and by the use of more costly modes of transportation. At the same time, a large portion of the Great Lakes fleet halts operation and lays up, resulting in increased yearly operational costs to the owners because the vessels are not producing income, but the fixed costs (depreciation, vessel cost, etc.) are still paid. These costs show up during the active shipping season which must be passed along to the shipper during the balance of the season and ultimately to the public in increased product cost.

The close of the Great Lakes-St. Lawrence Seaway shipping season by winter weather conditions also has a negative impact on employment: lay-offs occur. Some of the Nation's largest ports close down, and capital-intensive cargo handling equipment is idled.

In the past, extraordinary circumstances such as steel strikes (1956 and 1959), and at times of national emergency (January, 1945), operations at the locks at Sault Ste. Marie, Michigan, continued into the winter months to accommodate the urgent needs of the Nation for Great Lakes shipping. These circumstances indicated even then that certain types of winter navigation activities were at least engineeringly feasible.

*Prior study*

In recognition of the need to investigate potential benefits of an extended navigation season, Congress in

the 1965 River and Harbor Act *(Public Law 89-298)* authorized the U.S. Army Corps of Engineers to conduct a limited study into the feasibility for extending the season.

After a review of world-wide experience in ice navigation and ice modification techniques, this study concluded that the present state of technology was sufficiently advanced to make winter operation on the Great Lakes-St. Lawrence Seaway System physically feasible. The extent to which winter operation should be undertaken, and the economic feasibility for either limited or year-round extension, could not be determined on the basis of the limited investigations made in that study.

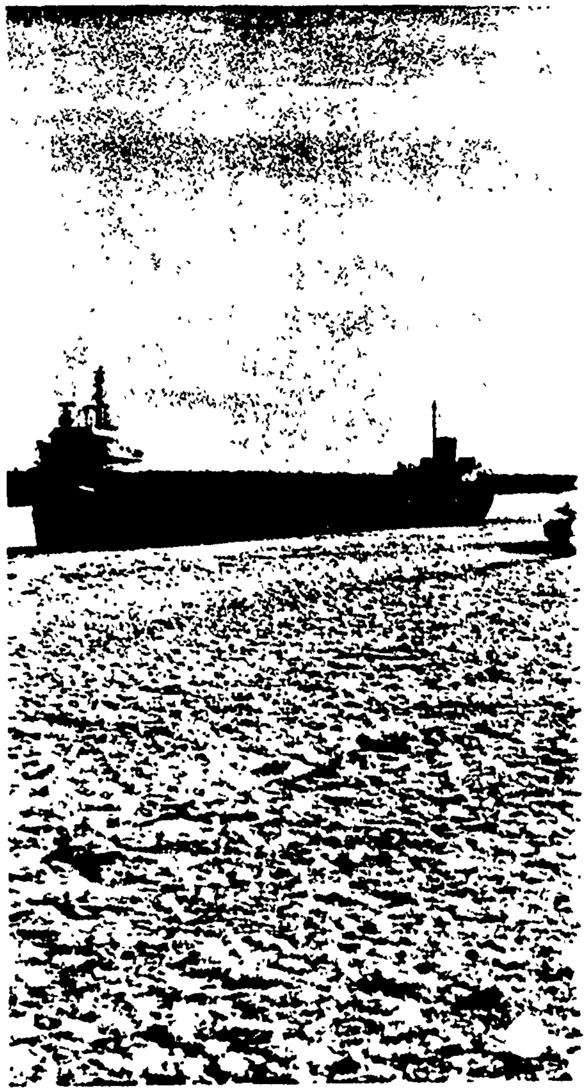
Traffic projection and estimated benefits clearly demonstrated sufficient economic potential to warrant further investigation. The initial feasibility study identified means by which problems associated with an extended navigation season on the Great Lakes-St. Lawrence Seaway System might be eliminated, and recommended that a full-scale study be undertaken.

*Current program authority*

The Great Lakes and St. Lawrence Seaway Navigation Season Extension Program is authorized by Congress in Section 107 of the River and Harbor Act of 1970 (Public Law 91-611). This authority is cited in its entirety on page 134. Section 107b has been amended twice since 1970. The program consisted of three parts, the Survey Study, the Demonstration Program, and the Insurance Study as follows:

*1. Survey Study:* A detailed survey study is underway to determine the economic justification, engineering practicability, and potential environmental and social impacts of an extended navigation season. This in-depth study is being conducted by the U.S Army Corps of Engineers with input from the Winter Navigation Board. The results of the Survey Study would provide the basis for Congress to determine the Federal interest in providing means for an extended navigation season on the Great Lakes and St. Lawrence Seaway. An interim Survey Report was submitted to the Board of Engineers for Rivers and Harbors in March 1976 recommending a limited season extension on the upper four Great Lakes (Superior, Michigan, Huron and Erie) to 31 January (± 2 weeks), utilizing for the most part basic operation measures and existing facilities. This Interim Report has been transmitted to Congress on 3 August 1979.

The final Survey Report, addressing several options up to a 12-month season on the system is un-



derway. The Survey Report would provide the results of the study and suggest additional measures which would be required beyond those previously recommended.

2. *Demonstration Program:* Through the Congressionally mandated action-oriented Demonstration Program the U.S. Army Corps of Engineers was directed to demonstrate the practicability of extending the navigation season on the Great Lakes-St. Lawrence Seaway System. Federal legislation directed the Secretary of the Army, acting through the Chief of Engineers, to carry out this program in cooperation with affected Federal agencies and non-Federal public and private interests.

The actions of the Winter Navigation Board in concert with private navigation interests have resulted in substantial extensions of the normal navigation season on the upper four Great Lakes in each of the eight years of the program. Year-round shipping was actually achieved in the upper four Great Lakes during four of the eight years of the Demonstration Program.

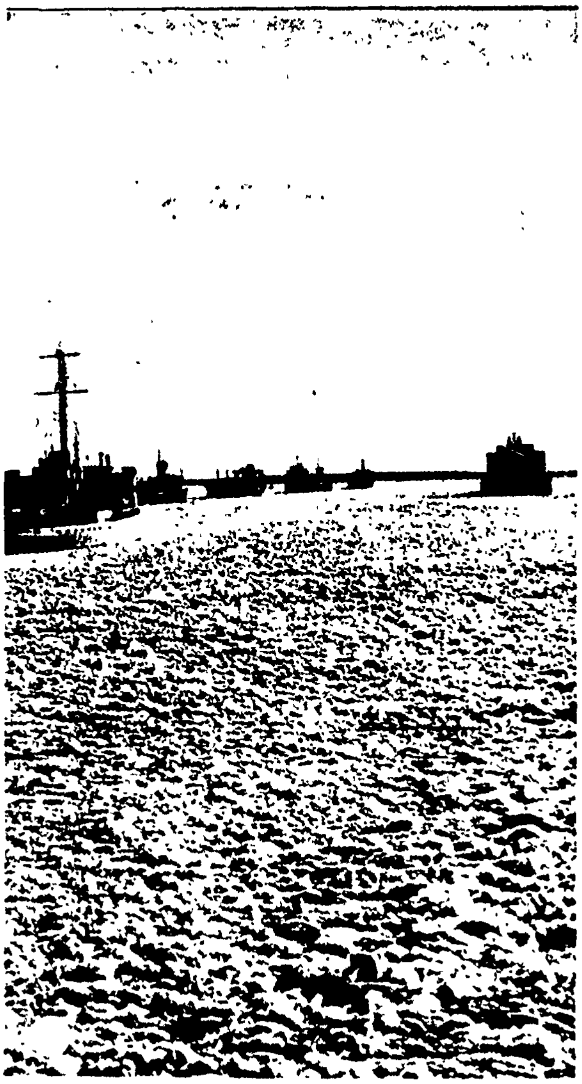
Modeling was conducted both before and in addition to actual physical methods for extending the season in the St. Lawrence Seaway.

This report, describing the results of the Demonstration Program, is submitted in compliance with the legislation.

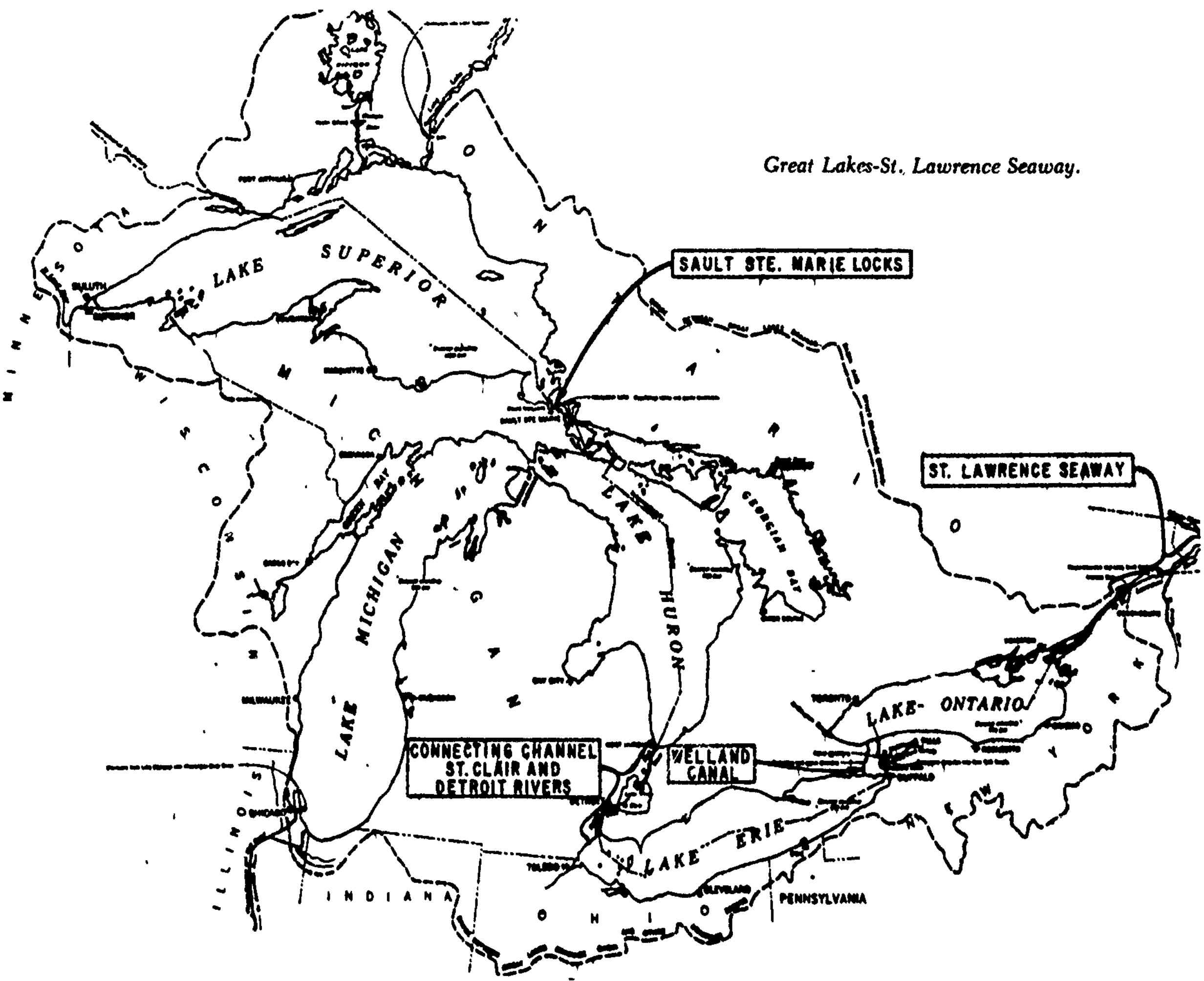
3 *Insurance Study:* The Secretary of Commerce, acting through the Maritime Administration, was directed to conduct a study to determine the means by which reasonable insurance rates could be provided for shippers and vessels engaged in waterborne commerce beyond the traditional navigation season. The Maritime Administration completed the study in 1972 and found insurance rates, although higher for the extended season, are not a major impediment to winter navigation. As the Demonstration Program proceeded, insurance underwriters redefined late sailings so that rate increases did not take effect until substantially later in the season.

*The geographic/economic region*

A brief glance at the geography of the Great Lakes-St. Lawrence Seaway waterway is helpful to an understanding of both the opportunities and the challenges implicit in winter navigation. The Great Lakes and their connecting channels contain a water surface area of over 95,000 square miles, of which about 61,000 square miles are within United States boundaries. The Great Lakes Basin comprises a large



*View of convoy.*




*Great Lakes-St. Lawrence Seaway.*

area of over 300,000 square miles, drained by the St Lawrence River through the Gulf of St. Lawrence into the Atlantic Ocean.

The Great Lakes provide a waterway over which 100 billion ton-miles of waterborne freight pass each year. Many commercial harbors serve the region including some of the largest in the Nation and two of the five largest U.S cities The distance from Duluth, Minnesota, at the western end of Lake Superior, to the Atlantic Ocean is 2,340 miles.

The Great Lakes Basin covers about 4% of U.S land areas and includes more than 14% of the Country's population One-sixth of the national income is earned in this region. Within the Canadian portion of the Great Lakes and St. Lawrence River Basin, the proportion of total population and economic activity is in excess of 60% of Canadian national totals.

The intra-region's transportation system, the Great Lakes, is critical in bringing raw materials from their sources in the upper lakes to industrial centers such as Chicago, Detroit, Cleveland, and Buffalo.

The St. Lawrence River connects the Great Lakes with the Gulf of St. Lawrence on the North Atlantic Ocean Since the international portion of the St. Lawrence River extends from Lake Ontario to a point below Massena, New York, the Demonstration Program activities pertain to this reach which is under the joint navigational control of the St. Lawrence Seaway Development Corporation, a corporate agency of the United States Government, and the St. Lawrence Seaway Authority of Canada. Below the international section, the river and the remaining Seaway locks lie entirely in Canada Year-round navigation from the Ocean to Montreal has been an

operational reality for many years due to Canadian efforts to extend the navigation season at that end of the St. Lawrence River.

*The Great Lakes fleet*

Completion of the 1,200' x 110' Poe Lock at Sault Ste. Marie in 1968 strengthened the economics of high volume, low cost waterborne transportation on the Great Lakes. The construction of several 1,000' x 105' self-unloading bulk carriers -- and several more under contract at Great Lakes shipyards -- has dramatically changed the future direction of the Great Lakes shipping fleet. A period of accelerated change in the size and shape of Great Lakes vessels is emerging as this new generation of larger, more sophisticated and more costly vessels move in to dominate roles in the ore and coal trades.

*Winter navigation problems in perspective*

Ice and its effects are the major physical impediments to winter navigation. On the Great Lakes, ice conditions are most severe in the upper four lakes and connecting channels: the St. Marys River between Lakes Superior and Huron; the Straits of Mackinac connecting Lakes Michigan and Huron; and the St. Clair and Detroit Rivers linking Lakes Huron and Erie. These connecting channels and the St. Lawrence River form natural constrictions in which the potential for ice jams and other problems implicit to winter navigation are most severe.

Icebreakers can open and maintain vessel tracks. However, sophisticated ice management techniques are needed to maintain stable ice fields and facilitate commercial ship movement in these channels and in harbors. The development of ice control techniques which will permit winter navigation while maintaining unimpeded river flow, for instance, is especially important on the St. Lawrence River. Here, ice booms have been installed at specific locations on the Seaway to assist in the development and maintenance of a stable ice cover, to prevent ice jams, avoid flooding, and assure an uninterrupted flow for the regulation of lake and river water levels and the production of hydroelectric power. These booms are closed each year after the close of navigation.

Proposals for extending the navigation season have raised many questions concerning environmental impacts, particularly in the connecting channels and harbors, and in the St. Lawrence River. It has become evident that extensive environmental studies would be

**SELF-PROPELLED VESSELS OF 1,000 GROSS TONS AND OVER AS OF NOVEMBER 24, 1978**

**U.S. GREAT LAKES FLEET**

| TOTAL ALL VESSELS | BULK CARRIERS # | BULK CARRIERS DWT | TANKERS # | TANKERS DWT | OTHERS[1] # |
|---|---|---|---|---|---|
| 159* | 143* | 2,848,825* | 6 | 40,643 | 10 |

[1] Railroad Cars-Passenger Car Ferries

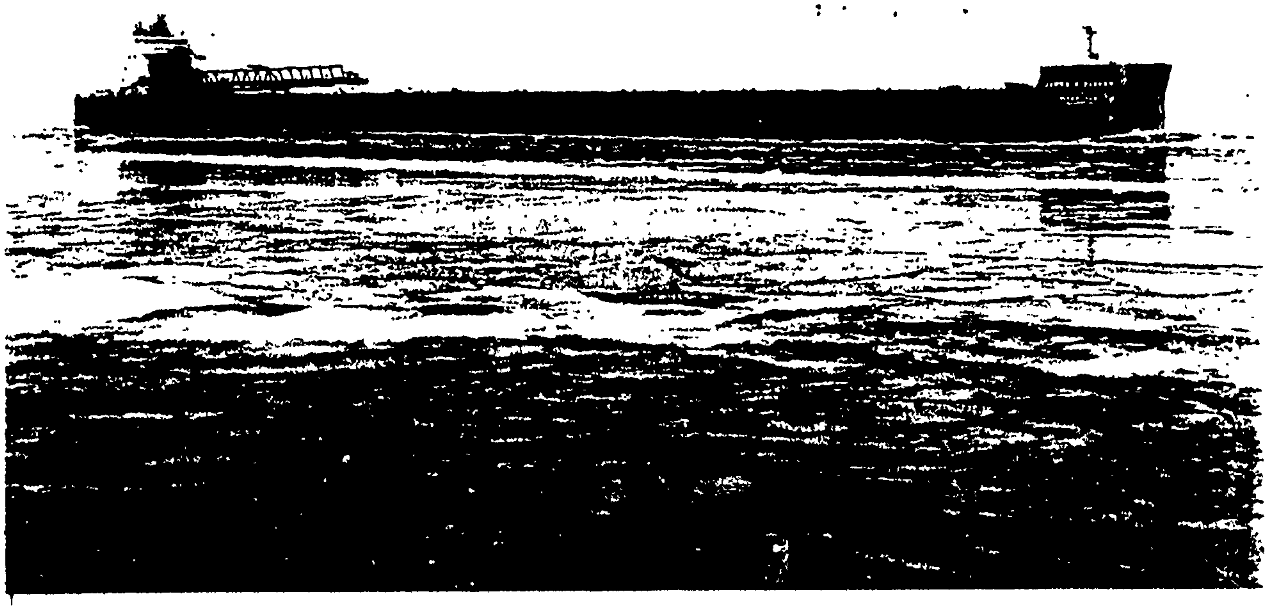
Source: Maritime Administration, Great Lakes Region
Greenwood's Guide to Great Lakes Shipping

*Includes integrated tug-barge "Presque Isle" of 52,000 DWT, which, for operations purposes, is considered a vessel.

As part of its ongoing program, as mandated by Executive Order of 1936, the U.S. Coast Guard's Ninth District headquartered at Cleveland, Ohio, provides icebreaking support to vessels beset in ice or in need of assistance to transit through the ice. For this task, and other assigned missions, the Coast Guard employs a fleet of twelve vessels year round including one major icebreaker. During the Demonstration Program an additional icebreaker was added for winter operation.

On 8 January 1979, the *Katmai Bay*, the first in a series of four new class icebreaking tugs to be received before the winter of 1979-80, was commissioned. The new vessels, replacing an older class, will greatly upgrade Coast Guard icebreaking capabilities in the Great Lakes

*The 1,000-foot carrier* James R. Barker *heads through ice towards the Soo.*



required if an environmental baseline were to be established. Such a baseline would allow for monitoring to detect and determine the extent of environmental impacts which might occur as a result of an extended season. Particular concern has been expressed over the possibility of oil spills in winter conditions and the organizational and technical capacity of both the government agencies and private industry to adequately react to that situation. The possibility of increased shoreline and structure damage resulting from the extended navigation season is also a major concern.

Other stated concerns over extended season operations include island access difficulties and the disruption of established recreation patterns, which might lead to declines in tourism.

Since conventional floating navigational buoys are removed prior to ice formation, the need arises for an all-weather navigational aid system to reduce the risk of groundings and collisions and to permit 24 hour navigation. Related to this are the needs for a network to collect and disseminate ice and weather data and the development of improved prediction techniques for ice freeze-up and break-up periods.

The safety of vessels and crews during winter season operation is also a primary concern. In the event of accidents on the system, it is important that an effective emergency locating system be implemented for both vessels and crew members and that safety and survival equipment for crew members exposed to icy waters be improved.

The location of the waterway between the United States and Canada requires that a cooperative effort be undertaken to obtain the implementation of an extended season. The Welland Canal, navigation link between Lakes Erie and Ontario, and the lower reaches of the St. Lawrence River are wholly in Canada, and therefore Canada needs to determine its interest in extended season navigation and the nature of its commitment.

*Winter navigation accomplishments in perspective*

In eight years of extended season tests and ice breaking operational activities, the Coast Guard has demonstrated the practicability of continuous commercial traffic under adverse winter ice conditions. Additionally, and in concert, many ice control and ice management concepts and methods were tested by the Corps of Engineers and other participating agencies; the most successful of which are briefly mentioned in this section, and described in the text that follows. Bubbler systems and the use of thermal effluents were tested for effectiveness in reducing ice cover. Model studies were conducted to gain insights into the effects of vessel transits on water levels and flows in the St. Marys, St. Clair, and St. Lawrence Rivers, and to test the effectiveness of different types of ice control structures.

Limited environmental studies were conducted to determine the effects of specific Demonstration activities on the environment, such as the effect of long line bubblers on fish movement, and some baseline data were collected, principally on the St. Marys River. The U.S. Coast Guard developed an Oil and Hazardous Substance Spill Contingency Plan and tested new methods and devices for oil spill containment and recovery. These activities were independent from the Demonstration Program.

To facilitate transportation to islands in the St. Marys River, the U.S. Army Corps of Engineers made and tested substantial improvements to the Sugar Island ferry and provided an air boat for use and testing by Lime Island residents. Studies were conducted along proposed vessel routes to determine possible impacts on recreational activities.

To enhance the safety of navigation under conditions of poor visibility, several systems have been tested under various authorities. They include the installation of a magnetic wire on the channel bottom, a laser light range, a radar navigation system, radar transponder beacons (RACONs) and a limited Long Range Navigation (mini Loran-C) system in the St. Marys River. Prototype ice buoys were tested as replacements for regular light and radar buoys which are removed prior to ice conditions.

The U.S. Army Corps of Engineers and the St. Lawrence Seaway Development Corporation (SLSDC) gathered data on ice and weather conditions throughout the Great Lakes. This information was channeled through the Coast Guard's Ice Navigation Center in cooperation with reporting stations established by the National Weather Service. These units provide up-to-date information on ice and weather conditions, including ice forecasts (from techniques developed by the Great Lakes Environmental Research Laboratory), ice outlooks and ice charts in support of extended season shipping.

The U.S. Coast Guard also has tested several survival suits, survival craft and position-indicating transponders for emergency use by vessel crews. Both survival suits and position indicating transponders have been adopted by vessel operators.

Canadian interests have been represented on the Winter Navigation Board as observers since the inception of the program. A Joint U.S. and Canadian Guide for Icebreaking was developed and implemented independently from the Demonstration Program. Additionally, direct coordination between the St. Lawrence River operating agencies (e.g., St. Lawrence Seaway Development Corporation and St. Lawrence Seaway Authority) has occurred throughout the program. Canadian vessels have operated on the Great Lakes later into the season as a result of extended navigation season measures and the St. Lawrence Seaway Authority has made improvements in the Canadian portion of the Seaway to facilitate operation in ice conditions.

*Unresolved winter navigation issues*

One of the stated goals of the Demonstration Program was the accomplishment of vessel transit tests, under severe winter ice conditions, in the St. Lawrence River. Notwithstanding that many ice control measures, tests, and investigations have been carried out in the eight years of Demonstration Program, activities, including limited vessel transit of ice booms, the desired goal could not be accomplished.

Unresolved issues include the model predictions of effects on the level of Lake Ontario and flows in the St. Lawrence River. Disruption of these flows have potential impacts on power production. Associated with flows and disrupted ice conditions are many environmental questions which numerous private and State groups in New York, including the Governor, feel need to be addressed before any demonstration oc-

curs. Concern has also been raised that the demonstration activities cannot proceed without formal coordination and approval of the Canadian Government.

These critical issues affecting vessel transit tests on the St. Lawrence River, were addressed by the Winter Navigation Board in a resolution passed by a 9 to 4 split vote on 11 January 1979:

Be it resolved that:

1. The Chairman, on behalf of the Winter Navigation Board, shall communicate to Congress the sense of the Board regarding the Winter Navigation Season Extension Demonstration Program, through the Chief of Engineers and the Secretary of the Army, to the effect that the Board:

2 understands its obligation to provide to the Congress timely recommendations on its findings and conclusions concerning the demonstration program and the public funds appropriated for its support.

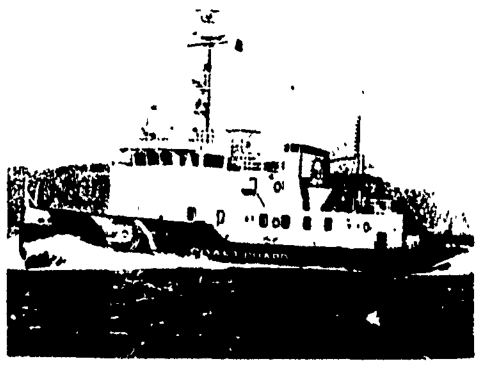
3. understands the purpose of the season extension Demonstration Program is to demonstrate the practicability of navigation on the Great Lakes and St. Lawrence Seaway System during conditions of ice cover.

4 wants to be responsive to the concerns of environmental and conservation interests in the conduct of a season extension demonstration program.

5 recognizes that it cannot achieve agreement between the various interested parties with regard to the environmental and ecological investigations, including an investigation of measures necessary to ameliorate any adverse impacts upon local communities, requisite to demonstration on the St. Lawrence River, and that demonstration of winter navigation on the St Lawrence River will not be possible within the current authorization of Section 107(b), P.L 91-611.

6 recognizes that the time and financial constraints which the Congress placed on demonstration program activities prevents undertaking exhaustive environmental baseline studies, however justified such studies might be for post-authorization activity,

and, further, that the Board·



*The new 140-foot Coast Guard Cutter* Katmai Bay.

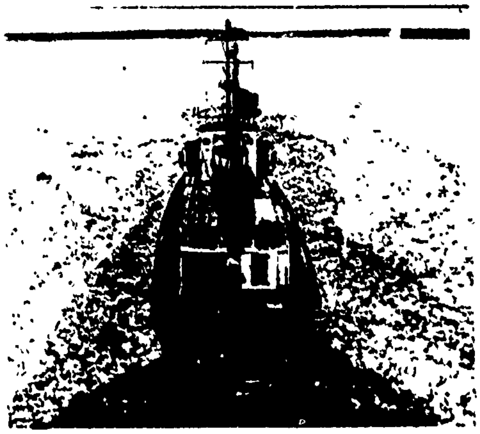
*Pack ice in Lake Superior.*

7. believes, on the basis of actual experience and operational activities on the upper Great Lakes and the lower St. Lawrence River, on the basis of the 1976 Interim Survey Report, that substantial evidence exists to support a finding of technical and economic feasibility, except on environmental matters in the St. Lawrence River,

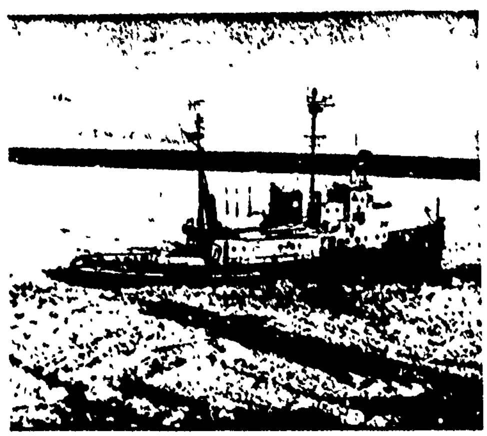
8. recommends either: (a) a substantial extension of the Demonstration Program on the St. Lawrence River to accommodate the stated environmental objections; or, (b) that as an alternative to further demonstration on the St. Lawrence River, which cannot be accomplished under current authorization, and in order to comply fully with the investigative request of Congress, that the feasibility report scheduled for completion in FY 1980 under Section 107(a), P.L. 91-611, include provisions recommending post-authorization accomplishment of the St. Lawrence River demonstration program objectives, particularly development of navigable ice booms, vessel transit tests, and investigation of measures necessary to ameliorate any adverse impacts upon local communities,

9. supports the early completion of the final feasibility report and its expedient processing to the Congress, while recognizing that any additional environmental studies which Congress deems necessary may be authorized and funded through an extension of the demonstration program, or some other directive,

10 recommends that remaining unobligated funds in the demonstration program, as appropriate and to the extent necessary, be used to assure completion of the feasibility report and to initiate action suggested by agencies, as approved by the Board, as prerequisite to carrying out planned demonstration activities in the St. Lawrence under current authority.



*Aft view of the* Naugatuck.



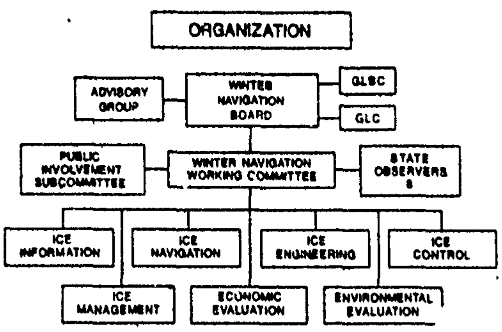
*The* Raritan *in heavy ice.*

## Part II: The Demonstration Program: A Final Report

*Organization*

The chart on page 30 portrays the organizational structure of the Winter Navigation Board Under the terms of a Memorandum of Un-

derstanding (see page 135) signed by the participating Federal agencies, the Great Lakes Basin Commission (GLBC) and the Great Lakes Commission (GLC), the Winter Navigation Board (established in July 1971) prescribed the organization and procedures for managing, coordinating and reporting on the Demonstration Program. The Board is composed of interested Federal and regional agencies, an industry and a labor representative, an Advisory Group formed to provide input from shipping and industrial interests, port authorities, and other non-Federal public and private interests, and a Great Lakes representative for all the Great Lakes States. Observers to the Board include the International Joint Commission, the Department of State, and from Canada, the St. Lawrence Seaway Authority and the Canadian Coast Guard. Technical advisors to the Board represent the National Aeronautics and Space Administration and the Energy Research and Development Administration.




A working committee, constituted similarly to the Winter Navigation Board, has carried out the program activities approved by the Board. Seven work groups, each headed by a lead agency and assisted by associated agencies, have conducted activities in their functional area. Also, attached to the working committee has been a public involvement subcommittee as well as state observers from each Great Lakes State.

*Strategic concept*

The impetus from private industry to engage in extended season shipping has been fundamental to the concept of the Demonstration Program. Activities under the program have been aimed at developing and, where possible, testing new or improved methods for facilitating commercial ship voyages. These activities have included finding solutions to winter navigation problems, the results of which have provided valuable input to the survey study.

Several principles formed the keystone of the Board's concept regarding both types and locations of activities undertaken:

1. A system approach has been essential in order to address all significant requirements of winter navigation on the Great Lakes-St. Lawrence Seaway System. High priority was assigned to the most significant requirements or problems.

2. While different conditions throughout the Great Lakes and St. Lawrence Seaway have required different solutions, methods or approaches tested have been adapted elsewhere in the system, wherever possible.

3. To assure validity of demonstrations, new techniques have been tested at the most difficult passage areas along major vessel routes, including the St. Marys River, the Straits of Mackinac, the St. Clair and Detroit Rivers and St. Lawrence River.

*Program funding*

Under the River and Harbor Act of 1970, $6.5 million were originally authorized for a three year demonstration program. The Water Resources Development Act of 1974 increased the amount to $9.5 million and extended the program 2½ years. The program was further extended another 2½ years and the funding increased to $15,968,000 by the Water Resources Development Act of 1976.

The Winter Navigation Board has allotted a total of $13,668,000 for the eight years of the program. These funds were distributed to the work groups for the various programs as shown in Table A. $2,300,000 were revoked, because time constraints precluded accomplishing several FY 79 activities in the St. Lawrence River.

*U.S.C.G.* Naugatuck *at Soo Locks.*

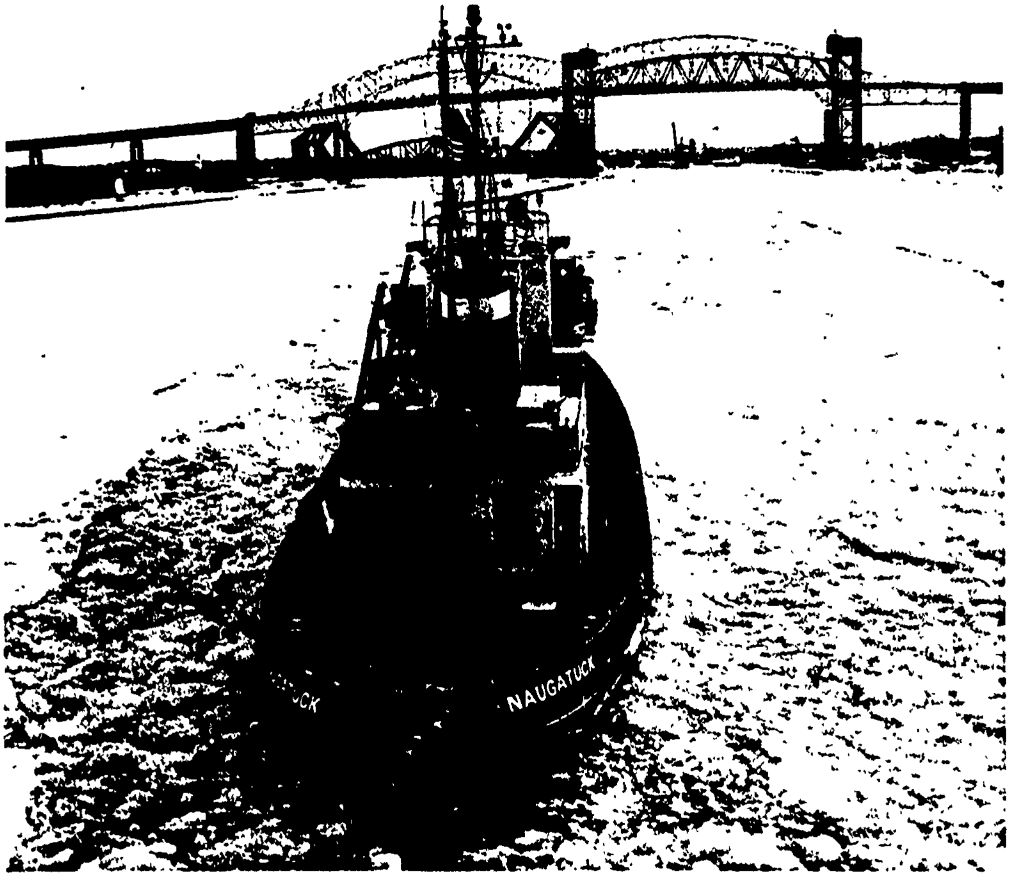



TABLE A

Demonstration Program Funding Allocation

| Program Element | Total FY 72 - FY 79 |
|---|---|
| Ice Information | $ 2,066,200 |
| Ice Navigation | $ 2,428,000 |
| Ice Engineering | $ 668,400 |
| Ice Control | $ 1,877,500 |
| Ice Management | $ 3,118,700 |
| Economic Evaluation | $ 143,900 |
| Environmental Evaluation | $ 1,609,600 |
| Program Management | $ 1,474,700 |
| Public Information Subcommittee | $ 93,200 |
| Reallocated to Survey Study | $ 187,800 |
| TOTAL | $13,668,000 |

*Taconite pellets.*

## Part III: Yearly Summaries of Activities FY 72-FY 79

*FY 72*

The first year's results were encouraging. When a U.S. ore carrier made the final transit of the Soo Locks in the St. Marys River on 1 February 1972, its passage marked the first time in history that commercial navigation between Lake Superior and the lower lakes had continued into the month of February

Nearly 2,000,000 tons of cargo were shipped through the St. Marys River during the extended season, more than half of which was iron ore.

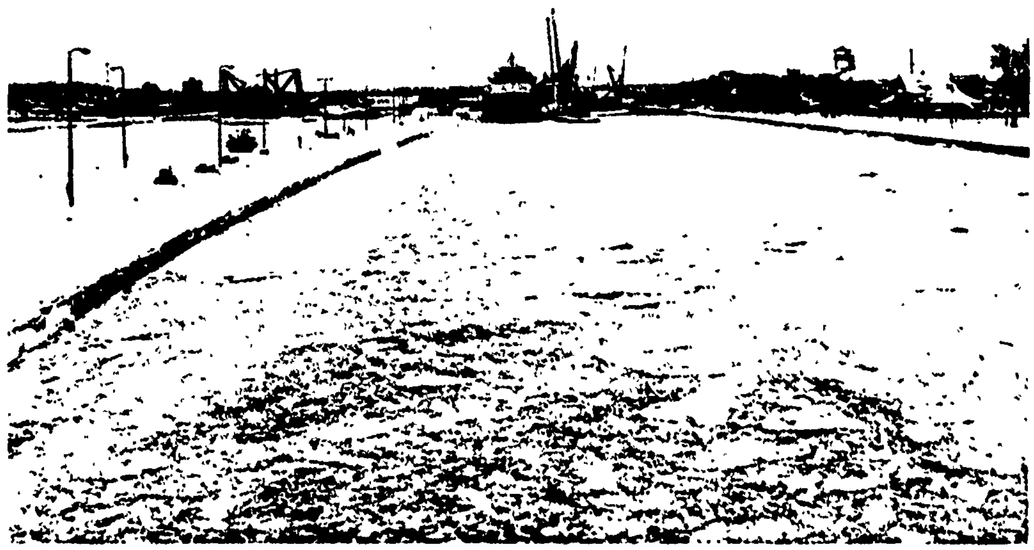
Tests of a 3,000 foot air bubbler line placed on the River at a difficult turn in the channel by Lime Island proved successful in preventing the heavy ice formation which normally occurs at this bend Several navigational aids indicated sufficient promise to warrant further testing under the program.

Much information was acquired on ice conditions throughout the system, and improved techniques were developed for collecting and disseminating such information and forecasting future ice conditions. Preliminary data was obtained on the pressures exerted by ice on structures.

Traffic continued on the St. Lawrence River above Montreal until 20 December 1971. After the close of the navigation season the power entities then completed closure of the two ice booms which cross the navigation channel in the International Section of the River Designs for a movable gate in the Ogdensburg Boom were prepared in anticipation of a field test.

*FY 73*

The Great Lakes navigation season of 1972-73 through the St Marys River was again increased sub-



*Exiting the Soo Locks.*

stantially, running from 5 April 1972 through 8 February 1973. This was the second year the shipping season extended into February. Total tonnage through the St. Marys River during the FY 73 extended navigation season increased to 3.36 million tons, exceeding the previous year by over a million tons.

Extension of the navigation season on the St. Lawrence Seaway in 1972 stretched to 23 December. In addition, the relatively mild winter permitted the opening of the 1973 navigation season on 28 March, resulting in the shortest closed period in history both for the Seaway and the Locks at the Soo (8 February to 1 April).

Among FY 73 Demonstration Program activities were several carried over from FY 72. These were the operation of the Soo Locks as late as necessary for vessel transits (Corps), the operation of the Ice Navigation Center at Cleveland (Coast Guard), and the Ice and Weather Forecast Operation (National Weather Service).

Also continued from FY 72 were ice surveillance and aerial reconnaissance activities and provisions for transportation assistance for island residents. The ferry, *Sugar Islander*, was modified to improve its ice operating capabilities.

New activities conducted in FY 73 included the use of an airboat for transporting residents of Lime Island across the ice covered channel, the testing of experimental ice buoys and anchors, and the successful testing of RACONs and survival suits. Plans were prepared for testing a thermal discharge ice suppression system in Saginaw Bay.

In conjunction with the St. Lawrence Seaway Development Corporation's ongoing program, a prototype ice boom gate was installed at Ogdensburg, New York, but was not tested under ice conditions due to objections of the power entities involved. They desired to develop a stable ice cover as early as possible to protect power generating capabilities. The original boom, installed late each fall by hydroelectric power interests, assists in the formation and maintenance of a stable ice cover. The movable gate, as installed, used floating barges on which gate-operating equipment was mounted.

*FY 74*

The FY 74 Great Lakes navigation season through the St. Marys River was extended to 7 February 1974, the third consecutive year that the season was extended into February. The total tonnage shipped through the Soo Locks increased to 4.78 million tons for the extended season. The shipping season on the St. Lawrence was extended six days in December beyond the 16th. The St. Lawrence River achieved its earliest opening date during the program (26 March 1974).

Activities at the Ice Navigation Center were continued throughout the Demonstration Program in conjunction with ice surveillance and aerial reconnaissance activities and ice and weather forecasts.

Studies of ice conditions in the St. Marys River were carried out to determine the effects of winter navigation on shore erosion and shore structures. Continued testing of the ice buoys in the St. Marys and Detroit Rivers demonstrated their effectiveness in ice conditions. Results of tests of modified Radar Transponder Beacons (RACONs) and a Precise Laser/Radar Navigation System were encouraging.

Additional adaptation and testing of survival equipment were continued, and survival suits were distributed to vessel crews operating during the FY 74 extended season under ice free conditions. Tests of the gate installed in the Ogdensburg-Prescott ice boom were continued and two vessel transits were made in late November 1973.

The air bubbler system in Duluth-Superior Harbor was operated for evaluation of environmental impacts and system effectiveness. The airboat at Lime Island continued to provide and test transportation service for island residents. Preliminary plans for a thermal ice suppression facility in Saginaw Bay were prepared, detailed design of the facility was initiated, and baseline environmental data were collected to provide for evaluation of environmental effects.

The bubbler-flusher system at the mainland dock of the Sugar Island ferry prevented excessive ice buildup in the slip. Ice accumulations in Little Rapids Cut, however, continued to interfere with ferry service. A scope of work was prepared for a model study of ice conditions in Little Rapids Cut to be conducted in FY 75 to determine the most effective long-range solution to the problem.

Draft reports on two systems studies were completed, one for the St. Lawrence River and one for the St. Clair-Detroit Rivers System. The systems studies determined the probable modifications, structural measures, and associated costs for extension of the navigation season in these locations.

*FY 75*

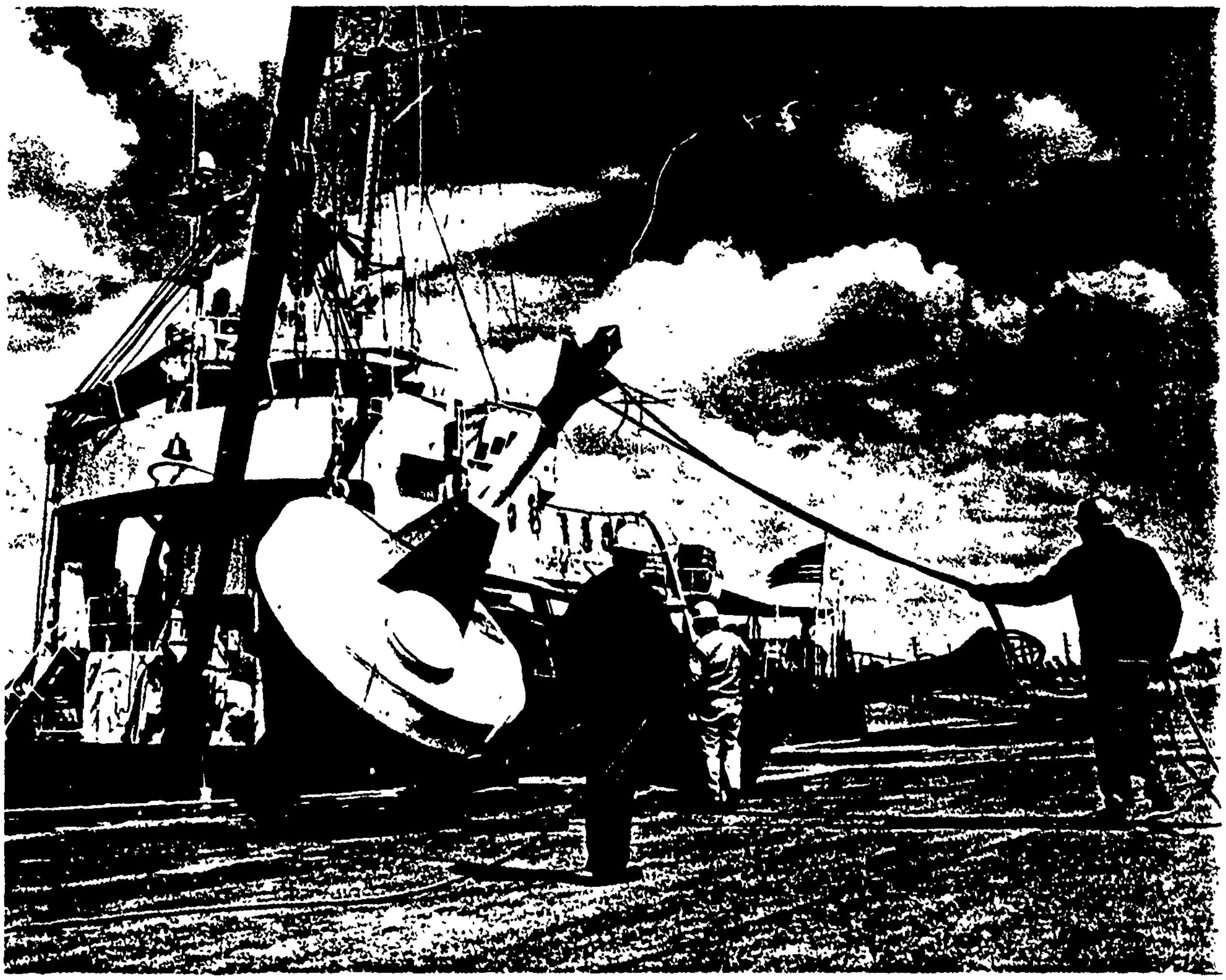
For the first time in history, the Great Lakes navigation season was extended to a full twelve months on the upper four Great Lakes. The tonnage passing through the Soo Locks for the FY 75 extended season (16 December - 31 March) was 9,134,539 tons, the largest total reached during the Demonstration Program. The large tonnage figure reflects the fact that the strike in the steel industry sharply curtailed the normal season shipment of ore which put a high demand on the need for shipping during the extended season to meet production needs.

Testing of ice buoys continued in confined waters of the Great Lakes and St. Lawrence River. RACON installations, as in past years, added significantly to safe vessel passages in difficult navigation areas. Field tests and demonstration of crew safety and survival devices focused heavily on individual and group exposure protection, distress alert and detection enhancement, and a man overboard alarm.

Tests of an ice boom designed to allow vessel transits were successfully completed at Copeland Cut in the St. Lawrence River. Model tests defined an optimum ice flushing system for the Eisenhower and Snell Locks. Measurements of ice forces on ice booms and piles were continued. An operational plan for the alleviation of temporary disruptions to ferry service in Little Rapids Cut in the St. Marys River was implemented. This included extensive efforts by the Coast Guard in the area of preventive icebreaking.

Improvements to the Lime Island airboat resulted in more satisfactory operation and improved passenger comfort. The bubbler-flusher system at Sugar Island performed satisfactorily throughout the extended season.

A model study of Little Rapids Cut in the St. Marys River identified a pair of ice booms as a poten-



*Experimental winter buoys are unloaded on St Lawrence River.*

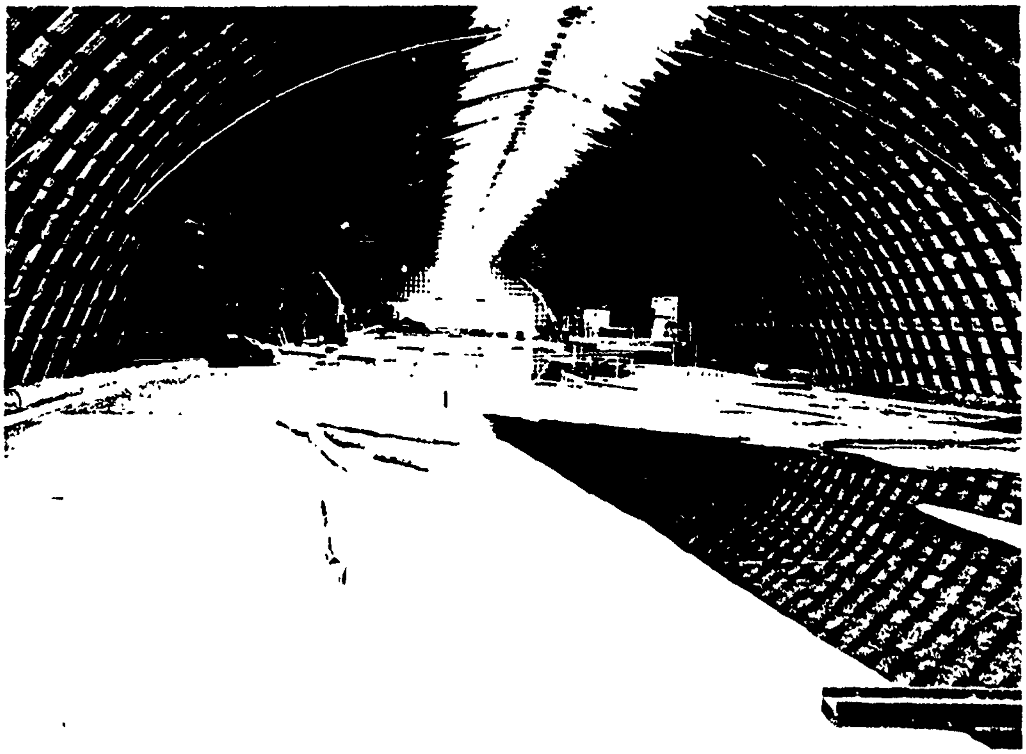
tially viable remedial measure to control ice floes in the Cut. During the winter of 75-76, the thermal ice suppression test on Saginaw Bay was installed. In order to evaluate the potential impacts of the thermal ice suppression test, the collection of environmental baseline data in the area surrounding the test site location was continued The System Plan for All-Year Navigation (SPAN) on the St. Lawrence River between Montreal and Lake Ontario was completed

During FY 75, icebreaking operations were directed more to preventive or maintenance icebreaking than in previous years, placing greater emphasis on keeping the channel open rather than responding to requests for assistance. This effort was particularly successful with ferry and ore boat traffic in the Little Rapids Cut area and in the St Marys River in general.

Following the adoption of Long Range Navigation (Loran-C) as the national navigation system for the coastal confluence zone, the Coast Guard installed a mini Loran-C system in the St Marys River to test its effectiveness in an area of narrow channels.

The St. Lawrence Seaway Development Corporation (SLSDC) contracted for the instrumentation and testing of an ice boom at Copeland Cut. The basic goal of the project was to collect data on the forces exerted on an ice control structure by water, wind, ice, and ships An additional goal of the project was to physically demonstrate that a vessel could navigate through an opening in an ice boom without disrupting the stability of an ice cover or the hydraulic integrity of the river. The data gained from the project has been used to calibrate mathematical and hydraulic model-

*View of St. Lawrence River ice model.*



ing techniques which would be used in future design optimization of other ice control structures in the St. Lawrence River.

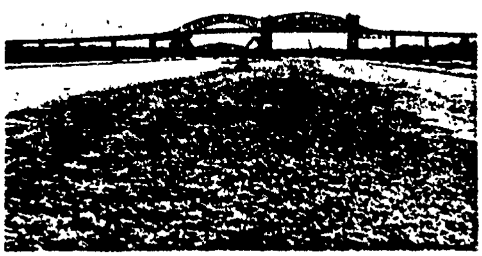
During the 1974-75 season, an operational plan was established for the St. Marys River to deal with the island transportation problem. It operated in successive years, anticipating potential ice problems to the ferry service, and improving methods of coping with temporary ferry interruption. The plan allowed for the complete termination of winter shipping should ferry service become seriously interrupted.

A model study was conducted of the Little Rapids Cut area of the St. Marys River in FY 75. As a result, a navigation ice control boom was installed to alleviate navigation-related ice problems. The boom, reinstalled in each consecutive year, has been augmented with additional ice stabilization structures, and closely monitored with strain gauges.

Other activities included an outdoor recreation study on the St. Marys River, a fish study at a proposed long line bubbler site, pressure wave measurements, and a study of effects of turbulence on water sediments and organisms.

*FY 76*

For the second consecutive year, the upper four Great Lakes operated on a twelve month basis. Tonnage of all cargoes passing through the Soo Locks in the St. Marys River reached 5.66 million tons, a decrease from the previous season, but in keeping with decreases in overall waterborne traffic throughout the world in 1975. The season on the St. Lawrence River ended on 20 December.



*Ice near the Soo Locks.*

The bubbler flusher system was again operated to assist the operation of the Sugar Island ferry. The Lime Island airboat was also tested this fiscal year. Further tests of electronic aids to navigation were performed, including RACONs, laser range lights, and precise laser radar navigation systems. Initial tests were performed on the use of mini Loran-C in the St. Marys River

Based on the results of the St. Marys River model study of the Little Rapids Cut, an ice boom with a navigation gap was installed above the Cut to provide a positive test of the ability of a boom with a navigation gap to retain ice when major vessels move through it.

A study was completed of the St Clair-Detroit Rivers System to identify measures necessary to extend the season in that system. A four part study plan for environmental baseline collection and preliminary evaluation of the St. Lawrence River was initiated by SLSDC. The studies included fisheries, recreation, shoreline erosion and structure damage, and potential effects on island transportation.

In addition, the St. Lawrence River ice breakup forecast was completed and became operational in FY 76 and the Saginaw Bay thermal ice suppression system was tested.

*FY 77*

The winter of 1976-77 was particularly severe, causing the demonstration effort to close down during the month of February for an 11-month season on the upper four Great Lakes. Tonnage shipped through the Soo Locks totaled 2.94 million tons. Contributing to the low tonnage totals for that season was the fact that ore inventories in the industrial centers of the lower lakes were high, giving the shipping industry the option of halting movement because of adverse weather conditions.

Although the Demonstration Program was halted for a brief period, shipping through the Soo Locks continued throughout the winter at the request of the Canadian government to enable it to ship emergency cargoes of fuel oil.

The shipping season on the St. Lawrence River again was extended several days beyond the traditional closing date, but the severe conditions delayed the opening of the river three days beyond the April target date.

Funding constraints limited FY 77 demonstration activities primarily to ongoing activities, including icebreaking operations, operation of the Ice Navigation Center, ice and weather forecasts, operation of the St. Marys River ice boom, and those activities necessary to insure island transportation for the St. Marys River area.

Other activities conducted were modeling of the Galop Island ice boom modifications and a continuation of environmental studies on the St. Lawrence River by the Department of the Interior.

*FY 78*

For the third time, the Demonstration Program extended the navigation season to a full 12 months on the upper four Great Lakes. Tonnage shipped through the Soo Locks rose to 6 84 million tons. The shipping season on the St. Lawrence was extended to the latest closing date of the program (26 December 1977); however, the season opening was again delayed two days beyond the target opening date.

The majority of this year's activities centered around the St. Marys River. The ice boom was reinstalled above the Little Rapids Cut, along with additional ice stabilization measures, and was monitored throughout the season The Lime Island airboat and Sugar Island bubbler/flusher were again tested and operated. A study was undertaken to determine effects of ship induced vibrations on shore structures. A limited shore erosion and dock damage protection study was undertaken.

A series of activities were undertaken to determine the effects of winter navigation in the area at the head of the St. Clair River, including a model study and field data collection. Environmental studies were continued on the St. Lawrence River and a study of macrobenthos was undertaken by the Department of the Interior in the St. Clair River.

The New York Department of Environmental Conservation (NYDEC) funded under the Demonstration Program conducted assessment studies to determine possible adverse effects of Demonstration Program activities on the St. Lawrence River

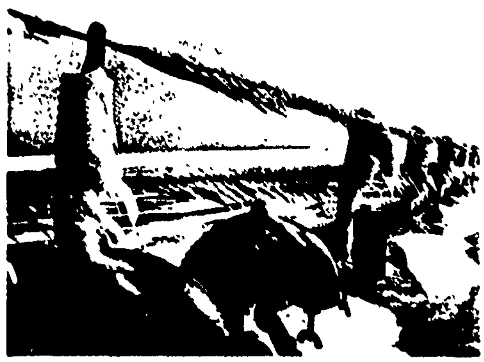
*FY 79*

Again in FY 79, the final year of the Demonstration Program, the navigation season on the upper four Great Lakes was extended to a full 12 months There were 536 transits through the Soo Locks during the extended season, carrying a total of 6.63 million tons of cargo Shipping on the St. Lawrence River continued until 22 December 1978.

During this final year of the program the same operational activities (as done in previous years) were conducted to provide transportation to the Island residents including the ice boom, stabilization islands, Sugar Island bubbler-flusher, and the Lime Island airboat.

A number of environmental studies were conducted during this fiscal year. These studies included an analysis of control sites within and outside the proposed demonstration corridor on the St. Lawrence River, a comparative study of the St. Marys and St. Lawrence Rivers, a St. Lawrence River fisheries study, a study of ship-induced waves in an ice environment, and a study of the effects of winter navigation on waterfowl and raptorial birds in the St. Marys River area.

Again this year, intensive studies were performed to document ice conditions on the St. Marys River. These studies included vertical aerial and time-lapse photography, aerial reconnaissance, ice thickness measurements, and the continuation of shore erosion, shore structure damage, and hanging dam studies. Ice marking and monitoring and measurement of water levels and air and water temperatures were also conducted. The Great Lakes Environmental Research Laboratory continued its efforts with both short and long range freeze-up and break-up forecasts.

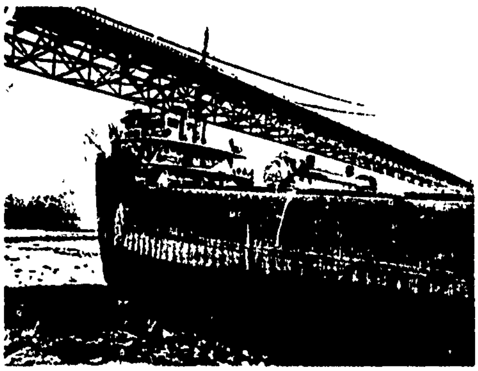


*A cold afternoon at sea.*

The National Weather Service installed additional equipment to receive weather satellite and Side Looking Airborne Radar reconnaissance imagery in an effort to improve the quality of ice forecasts and charts for Coast Guard and shipping operations.

A model study initiated in FY 78 was conducted in FY 79 of the St Clair River to determine the optimum design of an ice control structure at the head of the St. Clair River The study was supported by field data, including drogue studies to determine water velocities, measurement of under-ice water velocities, collection of additional weather data, and time-lapse photography of ice movement at the head of the St. Clair River.

Modifications to the Main Galop Island and Ogdensburg-Prescott ice booms to allow test transits



*Transit in the ice.*

of vessels were scheduled to take place in FY 79. These tests were indefinitely postponed because resolution of water levels and flow predictions from model studies could not be achieved and because environmental baseline data could not be obtained within the time limitations of the program authorization.

Opposition by private and governmental agencies of the State of New York was instrumental in focusing this lack of data. Additionally, the question of whether the State of New York, the International Joint Commission (IJC) or the Corps of Engineers had jurisdiction pertaining to the installation of booms, was not resolved.

Other studies conducted were: continuing tests of effectiveness of ice booms; the determination of forces on structures by both stable and moving ice; and demonstration of measures for dock structure protection.

The Coast Guard received the first in a new class of 140-foot icebreaking tugs which will replace some of the older vessels, greatly upgrading Great Lakes icebreaking capabilities.

## Part IV: Summary of Season Extension Results

The Demonstration Program activities were successful in substantially extending the season on the upper four Great Lakes during the entire program.

During the latter half of the program, the navigation season on the upper four Great Lakes was extended to a full twelve months. The closing date for the normal operating season for this system had been 16 December.

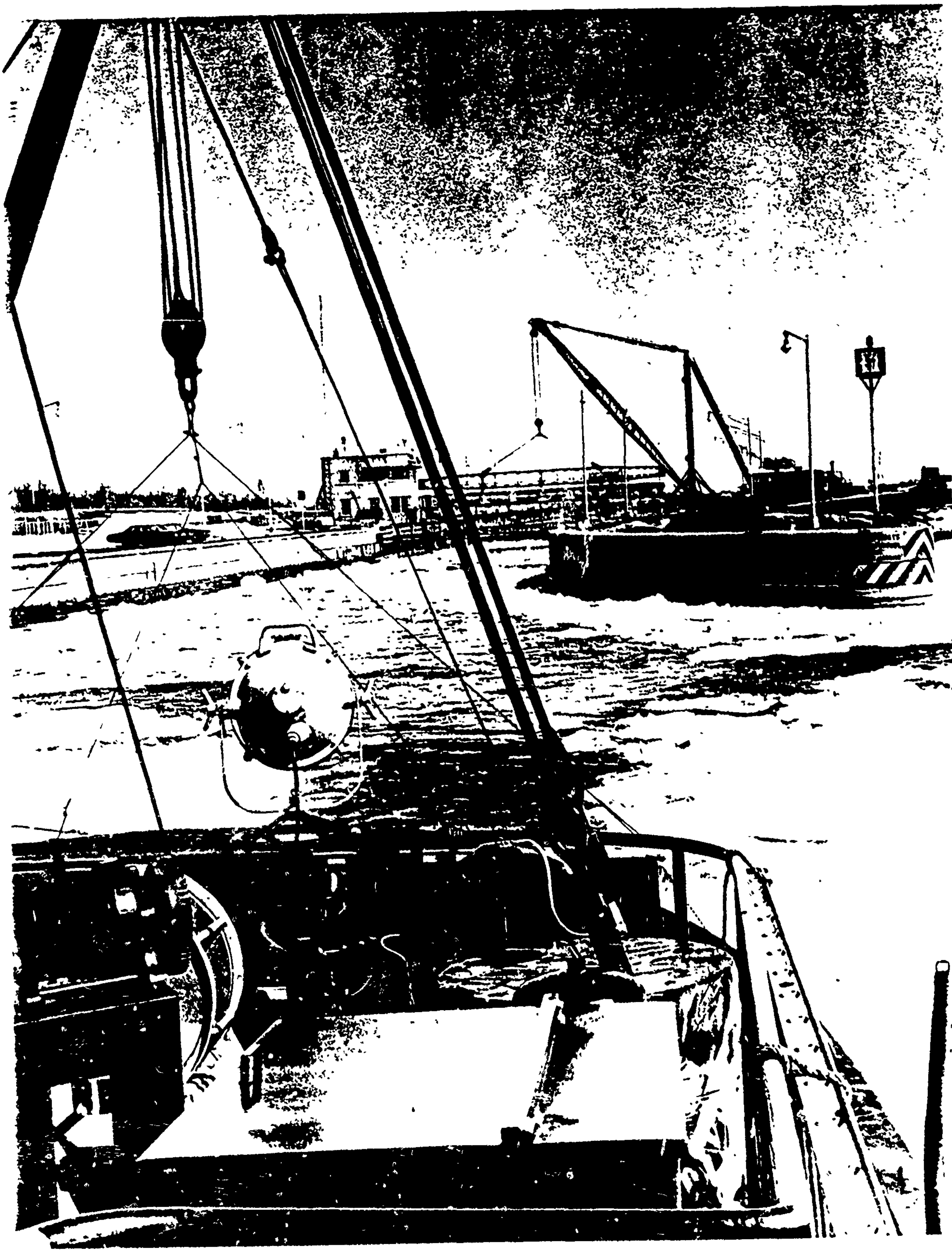
Over 41 million tons (approximately 4,000 vessel transits) of various cargoes were shipped through the St. Marys River during the extended season; more than half of this total was iron ore.

Much information was acquired on ice conditions throughout the system, and improved techniques were developed for collecting, disseminating and forecasting such information.

Traffic movement in the International Section of the St. Lawrence River above Montreal continued to 26 December, which was two weeks beyond the previously established closing date of 12 December. Ice boom improvements which will allow vessel movement through the booms have now been designed for this section of the River. Both physical and mathematical model studies have been conducted which indicate that minimal adverse effects will occur to the water level of Lake Ontario or flow of the St. Lawrence River. Because of time constraints, environmental and hydraulic questions could not be resolved, thereby precluding actual vessel transit tests in the area.

A significant portion of the resources for the Demonstration Program was used to investigate supporting systems for winter navigation season extension. The basic information collected from continued development of ice forecast techniques, data acquisition, surveillance of ice conditions, and special studies will be useful as a partial data base against which to compare future evaluations of the environmental effects associated with navigation season extension.

The findings and conclusions derived from the Demonstration Program have been summarized in Part IV of the report beginning on page 129.



*Ice at a St. Lawrence River lock.*

# I. GREAT LAKES AND ST. LAWRENCE SEAWAY WINTER NAVIGATION: ITS BEGINNING

## The need

With the opening of the bi-national St. Lawrence Seaway in 1959, the Great Lakes-St. Lawrence Seaway became a navigable deep draft system, extending nearly half-way across the North American continent.

In the winter months, normally between mid-December and early April, the system is closed down by winter weather and ice conditions. The ports of the Lakes, among the largest in the Nation, with their giant gantries and their extensive cargo moving apparatus, are effectively closed and many of their people are without or seek other employment. Ocean vessels are excluded from the system and lakers head for winter mooring. Normal waterborne commerce all but stops.

The industrial heartland of America, which calls upon water transportation to provide its raw materials, reverts to more costly means of supply: the stockpiling of materials for continuing operation during the winter months or shipping by overland modes.

For many years and particularly since the opening of the Seaway, commercial shipping interests have considered the potential of an extension to the navigation season. Car ferries, in fact, do continue to operate year-round and, weather permitting, coal is moved from Toledo to Detroit and various petroleum products are moved in Lake Michigan and the Detroit area. However, other upper lakes navigation was forced to cease during the winter months — in part because of ice conditions — but also because it was not practical to handle frozen cargoes, especially iron ore. Then the development of taconite pellets in the late fifties to extend the waning supply of iron ore in Minnesota and Michigan made winter material handling operations feasible. This led directly to renewed interest in the possibility of extending the navigation season into the winter months.

The basic purpose of the Demonstration Program was to demonstrate the practicability of extended season navigation, utilizing for the most part, existing knowledge and current technology. An associated purpose was improving the state-of-the-art where existing technology was unable to cope with the problems.

## The system and the region it serves

The Great Lakes Basin, including the five Great Lakes — Superior, Michigan, Huron, Erie and On-

tario -- comprises a land area of over 300,000 square miles drained by the St Lawrence River through the Gulf of St. Lawrence into the Atlantic Ocean. Combining the St. Lawrence River, the basins of lakes and lakeway channels, the waterway encompasses some 95,000 square miles. The principal connecting channels in the system are the St. Marys River between Lakes Superior and Huron, the Straits of Mackinac between Lakes Michigan and Huron, the St. Clair River-Lake St. Clair-Detroit River system between Lakes Huron and Erie, and the Welland Canal between Lakes Erie and Ontario.

Navigation locks are located on three sections of the system: on the St. Lawrence River; on the Welland Canal; and on the St. Marys River (Soo Locks). The locks provide a lift of nearly 580 feet, between Montreal and the head of the Great Lakes. Lake vessels 1,000 feet long and 105 feet wide can traverse the largest of the five parallel locks at Sault Ste Marie in the St. Marys River. Below Lake Erie vessel size is limited by lock dimensions to 730 feet in length and 76 feet in width. The channels and some 30 major harbors in the system have been improved through dredging to maintain a 27-foot controlling depth below low water datum.

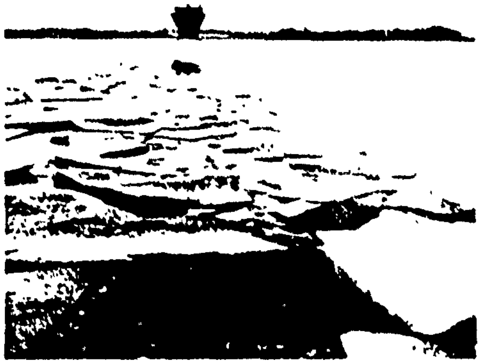
Depth over the sills of all locks in the St. Lawrence River and the Welland Canal is 30 feet. At the Soo Locks the depth for the MacArthur and Poe Locks are 31 and 32 feet, respectively, allowing transit of vessels drawing up to 25 feet 6 inches through the entire Great Lakes/St. Lawrence Seaway system.

The Great Lakes region is defined as consisting of a 19-state, economically identifiable tributary area including the eight states bordering the Lakes (Minnesota, Wisconsin, Illinois, Indiana, Michigan, Ohio, Pennsylvania and New York) and eleven adjacent states (Montana, Wyoming, Colorado, North Dakota, South Dakota, Nebraska, Kansas, Iowa, Missouri, Kentucky and West Virginia). This 19-state region generates 25% of the Nation's general cargo traffic and 16% of the bulk cargo, including midwestern grain shipments.

In 1977 the Great Lakes-St. Lawrence Seaway System carried 186 million tons of cargo, including significant percentages of U.S waterborne traffic in iron ore (72%), coal (19%), limestone (76%) and gypsum (98%).

Two of the five largest U.S. cities with a population in excess of one million--Detroit and Chicago--are located on the Great Lakes. Based on 1970 figures, within the U.S portion of the Great Lakes Basin area are some 30 million people -- more

*Vessel transiting the St. Marys River.*



*View of ice conditions over air bubbler.*

*Vessel passes mark. r in St. Marys River.*

*Coast Guardsman works in winter dress.*

*Crew works under winter conditions*

than 14% of the total U.S. population. The Basin contains several national industrial centers and is oriented toward manufacturing. In fact, nearly four million people -- 35% of the business labor force -- are employed in manufacturing.

The Basin contains extensive mineral, forest, agricultural, and fish and wildlife resources. Nearly half of the Nation's steel production, 12% of its mining, and 37% of its grain emerge from the eight Great Lakes States alone. Also included within the Great Lakes Basin, of course, are heavily populated areas in the provinces of Ontario and Quebec, including the two largest cities in Canada--Toronto and Montreal.

## Congressional support

*Prior studies*

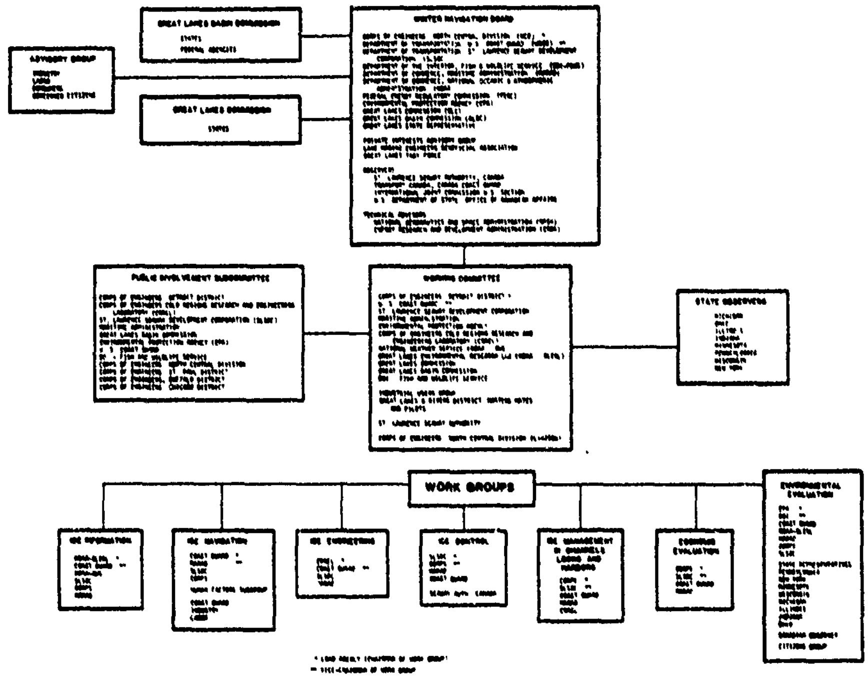
Prior to the authorization of the present Demonstration Program, Congress funded a conceptual study under *Sec. 304* of the 1965 River and Harbor Act *(PL 89-298)*. The purpose of this study, entitled *Feasibility Report on Great Lakes and St. Lawrence Seaway Navigation Season Extension*, was to provide a preliminary report on the practicability, methods and economic justification for an extension of the navigation season on the Great Lakes-St. Lawrence Seaway System.

The study identified precise problems of winter navigation that currently preclude general intra-lake, inter-lake and international navigation. It included a review of world-wide techniques and experience, and identified the existing and potential physical and economic means which might be used to eliminate - either partially or totally - the problems associated with navigation under total ice conditions. The report recommended that a full scale study of the Great Lakes-St. Lawrence Seaway System be authorized in order to determine means of extending the navigation season, including (but not limited to) a determination of costs, economic justification and the environmental effects.

*Current legislation*

The Winter Navigation Demonstration Program was authorized by Congress in Sec. 107 of the River and Harbor Act *(PL 91-611)*, approved 31 December 1970. The Program authorization is composed of three

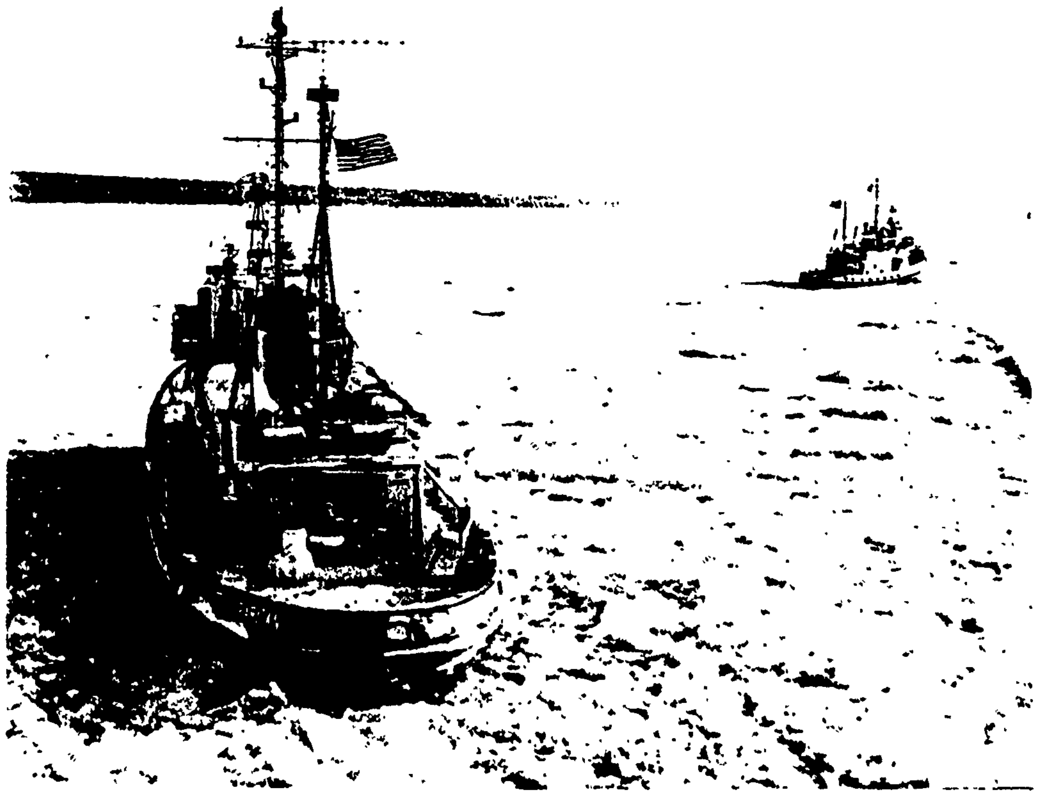
**ORGANIZATION CHART**
**GREAT LAKES ST. LAWRENCE SEAWAY**
**WINTER NAVIGATION BOARD**




parts: (1) Section 107(a); a Survey Study to determine the economic justification, engineering practicability, and environmental and social impacts of an extended navigation season, (2) Section 107(b); the Demonstration Program, an action program aimed at demonstrating both the practicability and the means of extending the navigation season, and (3) Section 107(c); a study of ways and means to provide reasonable insurance rates for shippers and vessels engaged in waterborne commerce beyond the current navigation season.

Section 107(a): **In partial response to the Survey Study authority an Interim Feasibility Study report dated March 1976 was prepared and recommended an** extension of the shipping season to 31 January (± two weeks) on an operational basis for the upper four Great Lakes -- Superior, Michigan, Huron and Erie -- and their connecting channels.

*Section 107(b)* of the Act stipulated that the results of the Demonstration Program should be submitted to Congress not later than 30 July 1974. However, *Section 70* of the Water Resources Develop-



*Coast Guard Cutter* Raritan *at work.*

ment Act of 1974 *(PL 93-251)* amended the submittal date to 31 December 1976, and the Water Resources Development Act of 1976 *(PL 94-587)* further amended the submittal date to 30 September 1979 and increased the total funds for the program to $15,968,000.

Many key problems identified in the initial conceptual survey study are addressed in the Demonstration Program to determine if the problems can be physically overcome to permit winter navigation in the system. The Demonstration Program Final Report does not contain recommendations. Only findings and conclusions concerning the results of the extended season effort through FY 79 are included in the report. The Demonstration Program is a test of methods for winter navigation. It does not address feasibility of season extension, and ends in September 1979 with the submission to Congress of this Demonstration Program Final Report.

*Task management*

The Demonstration Program is organized under the broad terms of a Memorandum of Understanding signed at the headquarters level by the represented Federal Agencies. The complete memorandum is cited on page 135. The Winter Navigation Board is established under the memorandum to direct the multi-agency organization. The Winter Navigation Board is composed of senior representatives of the participating Federal agencies and invited non-Federal public and private interests to coordinate planning, programming, budgeting, execution and reporting or investigations and demonstration activities.

The agencies represented on the Board are the Corps of Engineers, Coast Guard, St Lawrence Seaway Development Corporation, Department of the Interior, Maritime Administration, National Oceanic and Atmospheric Administration, Federal Energy Regulatory Commission, Environmental Protection Agency, Great Lakes Commission, and Great Lakes Basin Commission. An Advisory Group to the Board, formed to provide input from industry and labor, provides two members to serve on the Board. Additionally a representative of the eight Great Lakes states is a member of the Board. Observers from the St. Lawrence Seaway Authority of Canada, the Canadian Coast Guard, the International Joint Commission and the U S. Department of State are also included in the


Vessel at Soo Locks

Board structure, as well as technical advisors representing the U.S National Aeronautics and Space Administration and the Energy Research and Development Administration.

The Division Engineer, North Central Division, Corps of Engineers, serves as Chairman of the Winter Navigation Board; the Coast Guard Commandant, 9th Coast Guard District, is vice-chairman

A Working Committee, similarly constituted as the Board, directs seven Work Groups which carr out the program activities approved by the Board The Working Committee provides continuous coordination of program activities and develops and coordinates plans, programs, budgets, schedules, work descriptions, and reports for consideration by the Board The District Engineer, Detroit District, Corps of Engineers, serves as Chairman of the Working Committee.

The investigation and demonstration activities were divided among the seven program elements (Work Groups) with a Federal agency designated as lead agency for each. Each work group is listed with a brief statement of its objective

Ice Information (National Oceanic and Atmospheric Administration): Activities involved documenting ice-cover formation, movement, and decay; collection of operational data on ice and weather conditions, and the development of short- and long-range forecasts of ice conditions.

Ice Navigation (U.S Coast Guard). To provide safe and efficient movement of vessels through ice-covered waters

Ice Engineering (U S Army Corps of Engineers). To assess and advance the state-of-the-art in ice mechanics and engineering as required for winter navigation on the Great Lakes-St. Lawrence Seaway System, to develop adequate instrumentation and measurement techniques, and to develop design criteria for structures to withstand ice forces.

Ice Control (St. Lawrence Seaway Development Corporation): To demonstrate the feasibility of winter navigation on the St. Lawrence River.

Ice Management in Channels, Locks and Harbors (U.S Army Corps of Engineers). To develop and implement techniques, operating procedures, and ice control devices for effective and efficient vessel operation during the winter navigation season

Economic Evaluation (U S Army Corps of Engineers). To define items having economic feasibility for winter navigation on the Great Lakes and St Lawrence Seaway.

Environmental Evaluation (Environmental Protection Agency). Evaluation of environmental effects of specific demonstration projects that involved physical contact or interaction with the environment Provide supervision and guidance on the data needs, methods of evaluation, and preparation of the environmental assessments

Each lead agency was responsible for carrying out its element of the program utilizing its own manpower, but with support from other Government agencies and outside contracts, as necessary

The organization also included a Human Factors Subgroup within the Ice Navigation Work Group, and representatives of the eight Great Lakes states and the Sierra Club within the Environmental Evaluation Work Group

A State Observers Group represents individual states and provides liaison between the eight bordering Great Lakes states and the Working Committee. The observers report back to their states on the activities of the Demonstration Program and also report their state's interests to the Working Committee.

A Public Involvement Subcommittee of the Working Committee is composed of members of the various concerned government agencies, and was formed to keep the public advised of Demonstration Program activities. Contact with news media, the publishing of information bulletins, and the conducting of seminars are among the activities of the subcommittee.

A Legal Committee consists of representatives from the Corps of Engineers, St. Lawrence Seaway Development Corporation, Power Authority of the State of New York, and the Toledo-Lucas County Port Authority. The purpose of this Committee is to identify the legal questions and responsibilities related to an extension of navigation season into the winter months.

The program elements of the work groups fall into two primary areas: The Ice Information, Ice Navigation, Ice Engineering, Ice Control and Ice Management work groups comprise the action program dealing with the demonstration of the extended season's practicability within their designated areas of responsibility. The Economic Evaluation and Environmental Evaluation Work Groups are responsible for analyzing the environmental effects and economic costs of specific demonstration activities

*The Demonstration Program Final Report*

This report is divided into five main sections as follows:

1) The Winter Navigation Board Summary Report which contains a broad overview of the entire Demonstration Program.

2) Part I, a general review of the background of the program and the organization of the Demonstration Program effort

3) Part II: a description of the problems faced in an extended navigation season.

4) Part III: a discussion of the activities undertaken during the Demonstration Program together with the corresponding results.

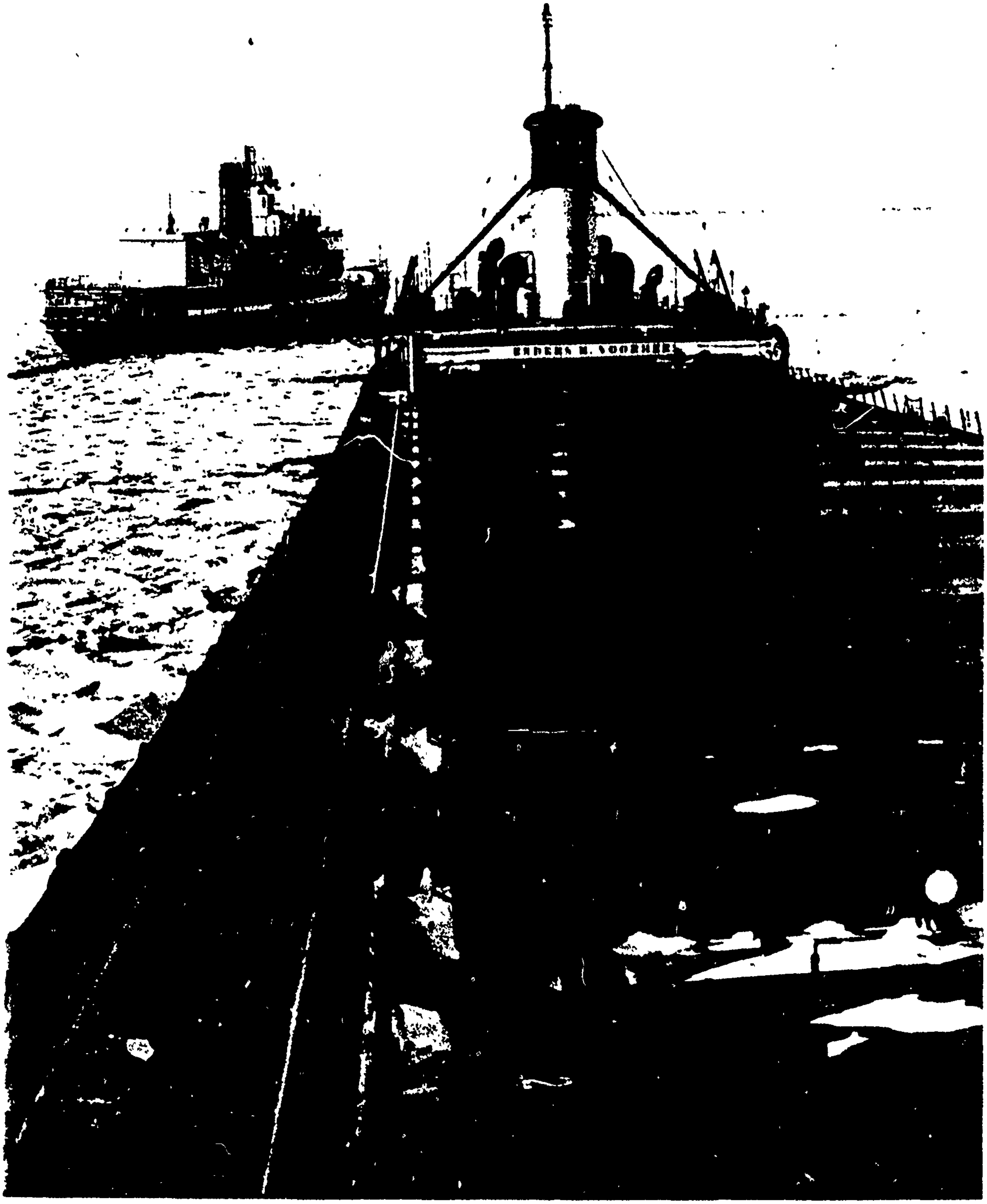
5) Part IV, an overview of the conclusion that can be drawn from the Demonstration Program activities.

**Other reports**

The activities, findings and conclusions during the first five years of the Demonstration Program, as indicated previously, have been described in four annual reports and a Demonstration Program Report prepared at the end of FY 76. Other reports dealing with key controversial issues have been prepared including the following.

A report, "Legal Considerations Associated with an Extension of the Navigation Season on the Great Lakes and St. Lawrence Seaway," was prepared by the Legal Committee. The Legal Committee was established to consider the problems that may result from activities conducted by the Winter Navigation Board and interested federal agencies to extend the navigation season. The areas of potential impact which were considered included damage incidental to navigation such as damage to locks, harbor facilities, and vessels. Other types of damage primarily ice related, included ice scouring of the shoreline, damage to shoreline structures, ice clogging of water intakes and sewage outfalls, and reduction of flows at powerhouses due to ice jams. While these types of damages may occur naturally it is felt by some that they may occur with greater frequency and potentially greater severity during an extended season with its associated ship movement in ice. The Legal Committee also advised the Winter Navigation Board as to the rights and liabilities of the United States with respect to an extended navigation season. The conclusions reached by the Legal Committee have been incorporated into the Survey Study.

A three-volume report, "Environmental Assessment: FY 79 Winter Navigation Demonstration on the St. Lawrence River," funded under the Demonstration Program, was prepared by the New York State Department of Environmental Conservation in cooperation with the State University of New York College, New York College of Environmental Science and Forestry. This environmental assessment suggested possible adverse environmental impacts of the proposed FY 79 Demonstration Program to the St. Lawrence River, and its terrestrial riverine ecosystems in relation to physical, biological and cultural resources. It was the explicit basis of the Commissioner of the New York Department of Environmental Conservation in concluding the risks of a Demonstration Program were too great without extensive and system-wide environmental studies being accomplished beforehand.



*Icebreaker runs interference.*

# II. OBSTACLES

This section contains a brief overview of the problems encountered with the extension of the navigation season on the Great Lakes-St. Lawrence Seaway. It is followed by a section discussing the activities undertaken to show these problems can be engineeringly overcome. Also in that section is a discussion of the results of those activities.

## Nature and ice

*General climate conditions*

The Great Lakes lie between latitude 41°21' N and 49°00' N and longitude 76°04' W and 92°06' W, at the confluence of major storm tracks that cross the North American continent. Because of the immense size of the Basin, a wide variety of weather conditions can exist at the same time.

The water volume (5,500 cubic miles) and surface area (95,000 sq. miles) of the Great Lakes act both to influence temperatures and function as a reservoir for the storage and exchange of heat energy with the atmosphere.

Average annual temperatures range from 39.0° F on Lake Superior to 48.7° F on Lake Erie, with minimum monthly temperatures generally occurring in January and February.

Precipitation in the form of rain, snow, and condensation is the source of water for the Great Lakes. The mean annual precipitation (1900 - 1978) for Lake Superior, Lake Michigan, Lake Huron, Lake Erie, and Lake Ontario basins are 29.7, 31.4, 31.4, 34.0, and 34.6 inches, respectively. The number of days having measurable precipitation ranges from an average of 169 days east of Lake Ontario and 155 days along the southern shore of Lake Superior to 119 days at the southern end of Lake Michigan.

*Winter climate*

The range of winter temperatures across the Great Lakes Basin can be seen by comparing the January monthly mean temperatures at Cleveland and Duluth: for the former, on the south shore of Lake Erie, 27.5° F and at Duluth 8.8° F, a difference of more than 18° F. These wide differences in temperature also account for variations both in severity and in the length of the winter season which, in turn, determines the extent of the ice cover on the Lakes.

The moderating effect of the Lakes on the temperature regime is pronounced during the winter, when mean lake temperatures may be as much as 30° F warmer than mean air temperatures. This differential results in high rates of evaporation which, when carried over land, creates heavy snowfall downwind of each of the Lakes. This effect is reduced, of course, when lake shores have become ice covered.

Seasonal snowfall in the region varies greatly from year to year, with annual snowfalls of less than 20 inches to the south of the lower Lakes, while annual snowfalls exceed 140 inches east and south of Lake Superior and east of Lake Ontario. Elevated areas east of Lake Erie can experience more than 100 inches during a normal winter. The St. Lawrence River area has an average snowfall of 80 inches.

*The* Leon Simard *at Thunder Bay oil dock.*

*Generalized ice conditions found in the Great Lakes-Seaway System*

A simple sequence of ice formation rarely occurs on the Lakes because of the variable weather conditions that prevail during the winter months. Extremely low air temperatures may occur for a number of days allowing an extensive, but thin, ice cover to form. The cold spell may be followed by warm weather and strong winds, and consequently the thin ice cover is broken up and concentrated on a lee shore or melted in the lake by upwelling warm water. The effects of winds, currents, and upwelling upon the ice cover causes its areal extent and distribution to change rapidly. Large lake-surface areas also influence the ice cover by causing it to react to water level fluctuations. Water level changes tend to keep the ice in a fluid state and make it more susceptible to wind and current action. It can be seen that ice cover on the Great Lakes is affected by many hydro-meterological factors, but each lake has its own characteristics that affect ice formation and distribution.

Many physical and environmental problem areas associated with winter navigation on the Great Lakes-St. Lawrence Seaway System involve four principal water navigation areas: (1) navigation channels, both interlake and on the St. Lawrence River, (2) harbors, (3) locks, and (4) open lake courses. They are affected by a wide variety of icing conditions. Ice in the connecting channels and river channels severely limits vessel movements, especially at channel bends in constricted areas and where ice booms have been installed.

## Moving through the ice

*Ice cover in lakes and harbors*

To move ships through the solid ice cover in lakes and harbors requires icebreaking assistance. The development of a means of retarding or suppressing ice formation would also ease the movement of ships. To some extent, shifting ice cover and wind-blown ice occur on all the Lakes. Drifting ice forms into large ice fields that shift with winds and currents. Icebreaker assistance is often required to maintain vessel tracks through this ice, primarily on Lakes Superior, Michigan and Huron, and at Lake Ontario's eastern end.

Lake Erie, the shallowest of the Lakes, may freeze over completely, and wind conditions can often shift ice over the vessel tracks. Large ice fields on the open Lakes are capable of trapping vessels and physically carrying them out of shipping lanes, possibly even running them aground.

In the shallower bays and straits of the more northern Lakes, where drifting ice is also prominent, high winds may pile ice into windrows and pressure ridges 10 to 20 feet above the water and 30 to 35 feet below, often anchored to the lake bottom. Windrows create difficulty to navigation specifically at the entrance to the Duluth-Superior Harbor at the western end of Lake Superior, Whitefish Bay and the upper St. Marys River at the foot of Lake Superior, the island areas of northern Lake Michigan, the Straits of Mackinac and the extreme eastern end of Lake Erie.

Ice floes and fields may be pushed by winds into harbor areas, occasionally halting vessel movement within harbors or through the entrances. Shifting or lessening wind intensity normally allows the floes or fields to drift back into the lake.

*Ice conditions in the rivers*

Where stable ice is disturbed by vessel movement or by winds and thaw conditions, the loose ice can move downstream and jam in constricted areas. Ice jams cause upstream levels to rise, and provide a flood threat to low lying areas. This happens frequently in the St. Marys, St. Clair, Detroit and St. Lawrence Rivers under natural conditions, regardless of ship movement.

Ice jams can also retard the normal flow of water, reducing the amount available for downstream power production, and can hamper ferry operations, increase shore erosion and structural damage.

Because the lengths of many vessels range between 600 and 1,000 feet, ice cover in the vicinity of tight turns or narrow channels tends to reduce the turning and maneuvering capabilities of the vessels. As a result, Coast Guard icebreakers are frequently required to work alongside a vessel to reduce friction resistance or to widen a turning area.

Power entities install ice booms to help establish and maintain stable ice covers, reduce the potential for ice jams and insure a steady current flow through intake gates. Ice booms are traditionally placed in the Niagara and St. Lawrence Rivers each winter. In the International portion of the St. Lawrence River, two booms extend across the navigation channel and remain there until just before spring navigation in late March.

*Other ice conditions*

As ice deteriorates and is broken up by winds, waves and pressure, it forms slush ice, one of the most difficult forms of ice to combat. Slush ice can close in around a vessel, preventing movement in any direction. It can damage propellers and steering gear, clog condenser intakes and exert pressure on the hulls of trapped vessels. This is a particular problem during spring break-up in Lake Erie, because the current and prevailing winds pack the slush ice into a shallow bottleneck in the eastern end of the Lake.

## Traffic control

Traffic control on the St. Lawrence River from Montreal through Lake Ontario and the Welland Canal to Lake Erie is accomplished using a joint system managed by the St. Lawrence Seaway Development Corporation and the St. Lawrence Seaway Authority of Canada. The system, which is premised on making the most efficient use of the Seaway locks, is a finite traffic control system which requires vessels to make radio calls establishing their positions at regular intervals. Vessels are tracked on an incremental basis, with the position of each vessel recorded as it passes designated calling-in-points The calling-in-points are located approximately one hour's sailing apart, under normal conditions and gives control operators complete information for any needed control of traffic flows and patterns. Additionally, this system provides vessel pilots and masters with a total scope picture of traffic, thus improving the safety and efficiency of transits

A first-come, first-served policy functions at the Soo Locks, with downbound and upbound vessels alternating through the locks. During winter operations at the Soo, however, the lockage of large ore carriers can result in lengthy delays to other ships. This is due, among other things, to the build-up of ice on lock walls as a result of the size of the vessels.

This problem has given rise to consideration of a lockage policy other than a first-come, first-served basis in order to more efficiently expedite shipping. The lockage of smaller ships (less than 105 feet wide) before the larger vessels, provided they are part of the same convoy, would keep shipping moving more rapidly without the problem of the ice coating of lock walls Other considerations that remain critical to such a judgement include the horsepower of the smaller ships, locking experience with wide ships, existing ice conditions, available ice tracks and an ability to pass. The basic policy of first-come, first-served in such cases would continue except where delays would be predictable

*Winter along the St. Lawrence Seaway.*

An extended navigation season will require precise traffic control on the upper lakes to assure the safety of participating vessels, particularly in the channel areas.

Navigation in narrow channels requires extra caution particularly in those areas similar to the Middle Neebish Channel in the St. Marys River and the Livingston Channel in the lower Detroit River These areas normally handle one-way traffic, but for an extended season they are required to handle traffic from both directions. New traffic regulations and a vessel traffic center may be required to expedite this kind of vessel movement.

Except on the Montreal to Lake Erie portion of the System there is currently no reliable method of determining if a vessel has been lost or damaged (aside from distress signals) until the vessel is overdue at its destination or until it has failed to file a routine report to its owner. Since the crew survival time is dramatically reduced during winter operations, an adequate vessel reporting system must be developed to help ensure vessel and crew safety.

To make a more efficient use of the Coast Guard's icebreaking fleet, a system needs to be developed to monitor proposed ship voyages and, where possible, form them into convoys.

*Vessel speed enforcement*

Speed regulations are the responsibility of the U S. Coast Guard and the St. Lawrence Seaway Development Corporation. These regulations are found in Title 33 Code of Federal Regulations (CFR) 92.49 (St. Marys River), 33 CFR 162.135 (Detroit-St. Clair Rivers), and 33 CFR 401.28 (St. Lawrence River).

Vessel speeds are monitored using Doppler radar or by measuring the time a vessel travels its own length. During the regular navigation season, vessel speeds are checked at random times of the day or night. During winter navigation, the level of speed monitoring is reduced commensurate with vessel traffic levels. Civil penalties are assessed for significant violations.

Excessive speed by vessels under both summer and winter conditions can increase shoreline erosion and damage to property. A program is underway to monitor vessel speeds, shoreline erosion and reports of property damage during winter sailings, to determine if speed limits need adjusting.

## Staying in the channels

### *Navigational requirements*

In the open waters and the larger bays of the Great Lakes, a ship's navigator requires all-weather aids to navigation to determine his position and to assist him in a safe transit.

Traditionally, in Great Lakes harbors and connecting channels, all lighted buoys and radar reflector-equipped unlighted buoys are withdrawn during late November or early December to prevent damage and/or loss of the aid during winter months. Some of these more sophisticated aids to navigation are replaced with unlighted buoys without radar reflector equipment. Such winter markers are barely adequate, representing a significant reduction in overall effectiveness.

In addition, the buoys are subject to submersion or movement off station by ice. Because of the obviously questionable reliability of floating aids used to mark channels during the winter navigation season, vessel personnel are often uncertain as to their vessel's exact position within a channel.

### *Navigational hazards*

Navigational hazards are also present during cold and stormy weather conditions when fog, low clouds, rain or blowing snow reduce visibility. In narrow connecting channels, ranges and similar aids are difficult to locate and radar, as now employed, is not sufficiently accurate.

Improved forms of navigation aids will be required for safe and efficient movement of vessels during the winter season. The establishment, for instance, of Loran-C in the Great Lakes will have an important influence on navigational accuracy. This all-weather system should be operational by 1980, enhancing present systems of coast lights, radio beacons, and fog signals. More precise navigation systems are required for the rivers and channels.

## Information to aid navigation

Weather and surface conditions found on the Great Lakes and their connecting channels differ markedly from those encountered during the bulk of the traditional shipping season. Winter storms historically can be severe on the Great Lakes (even though some of the most severe storms are in November and April). The harsh weather conditions during winter increase the difficulty of even simple tasks.

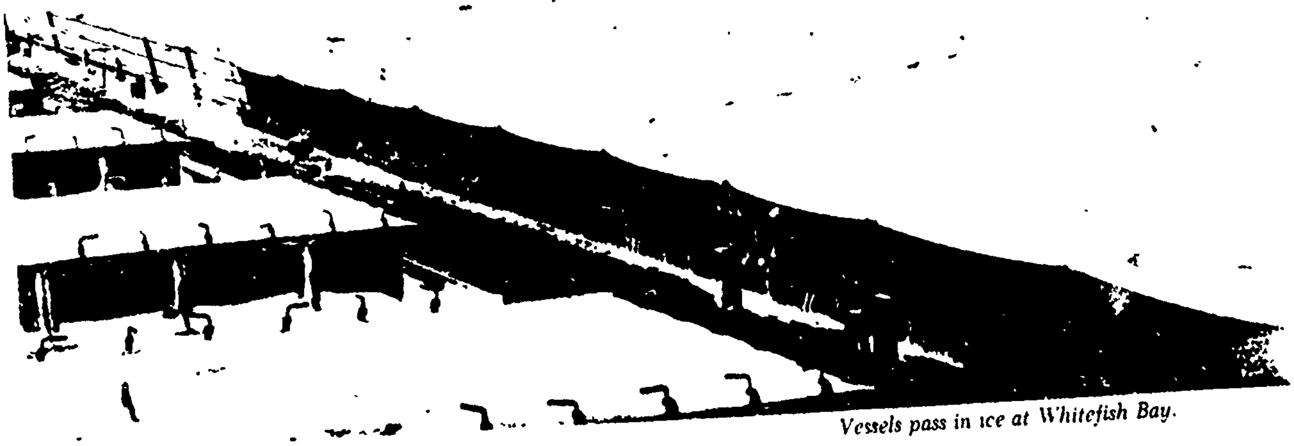
As previously discussed, ice cover causes varying problems throughout the Great Lakes-St. Lawrence Seaway System. To ease the impacts of these factors it is necessary to develop a comprehensive system of data collection for use by vessel operators and to provide a basis for predicting in advance adverse conditions so they may be avoided or prepared for. Coupled with this, an organization is needed to digest the data and take responsibility for getting the information and forecast to shipping personnel who require it.

The National Weather Service (NWS) has been disseminating weather forecasts and warnings to the Great Lakes shipping industry since 1870, and ice information since 1897. Extension of the navigation season to 12 months has required an increase of about 30 percent in the effort expended to make weather forecasts and an increase of several thousand percent in the effort devoted to ice forecasting. Most of the techniques and communication channels used are logical extensions and developments from those long used for the traditional navigation season. Loss of the "closed season" has removed the traditional wintertime respite which was used to review, reconsider, adjust, repair, and recoup. Needed changes can no longer be delayed until the end of the season, and are more likely to cause a noticeable interruption in the services.

## Problems of winter navigation

### *Potential vessel damage*

Some of the vessels currently operating in ice conditions have not been specifically designed for that purpose. Therefore, the potential for vessel casualties due to ice exists and is likely to increase as traffic increases. Regulations for the strengthening of hulls, reduction gears, rudder stocks and propellers may be required in the future. At present, several high-powered vessels



*Vessels pass in ice at Whitefish Bay.*

which routinely operate in ice as a result of the extended season have received some hull strengthening.

*Refuge area access difficulties*

In sudden storm conditions, heavy ice fields have been identified as potential obstructions to the quick and timely access of vessels to refuge areas. At the same time, however, such ice fields have a dampening effect on open waters and significantly lessen wind, current and wave action. This partially negates the potential damage which could arise from restricting access. The ice fields themselves become something of a refuge area.

*Adverse search and rescue conditions*

In open water areas, winter storm conditions can create both limited visibility and heavy seas, hampering rescue operations. The Coast Guard has had worldwide experience in search and rescue operations encompassing all types of weather and is well equiped to meet most navigation responses.

*Hazards to lock and dock personnel*

The extended navigation season creates problems for people working outside, especially at locks and on harbor docks, where extreme weather conditions can cause frostbite or hypothermia. Appropriate clothing and safety gear are obviously required.

Ice buildup on the sides of vessels moving along piers will sometimes shear off and shatter over work and walk areas causing potential personnel hazards. In addition, wind-blown snow frequently overhangs pier edges, obscuring them and causing a hazard for those who have occasion to walk to that edge. Ice on piers and heavy winds also cause problems with solid footing.

Hazards at locks are apparent in the removing of ice collars. Steam is used when it is available. Other more common methods include use of a back hoe, chipping with a bucket or modified ripper, or with a tractor-operated ice cutting chain saw. All of these methods of ice collar removal present hazards.

At times it is difficult and time consuming to close lock gates during winter navigation. This fact creates a potential problem should an injured person have to be brought across the lock to receive treatment

*Hazards to vessel crews*

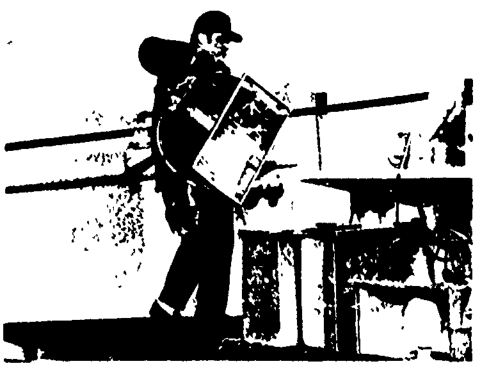
Vessel crews encounter many of the same hazards as those experienced by lock and dock personnel. Ice and snow can create dangerous footing situations on deck surfaces. Also wind and cold conditions may require special clothing for crew comfort and protection.

Additional hazards to vessel crews are encountered in cases of man overboard or an abandon ship situation. In such instances, the survival of personnel during immersion in water is dependent not only upon the victim overcoming the immediate danger of drowning, but upon individual reactions to stress associated with heat loss and thermofailure

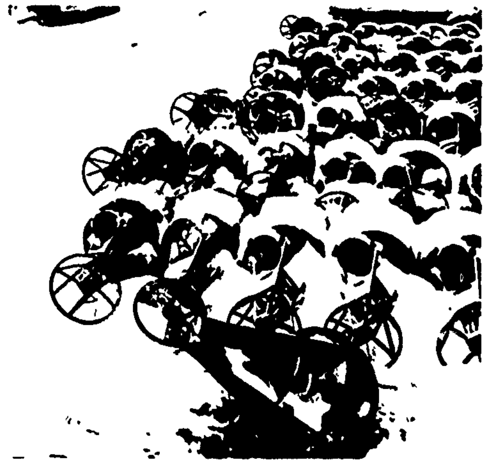
Immersion in water rapidly increases the victim's heat loss due to the decrease in the thermal insulation of his clothing. While common personal floatation devices and life rings enable a survivor to remain afloat, they are of no use in providing thermal protection or protection from wave action and spray.

Life boats and rafts are more effective in these situations because they remove the victim from the water and its effects However, life boats have problems associated with both launching and boarding in rough seas, and they lack adequate maneuverability. They also fail to provide adequate protection from wave spray

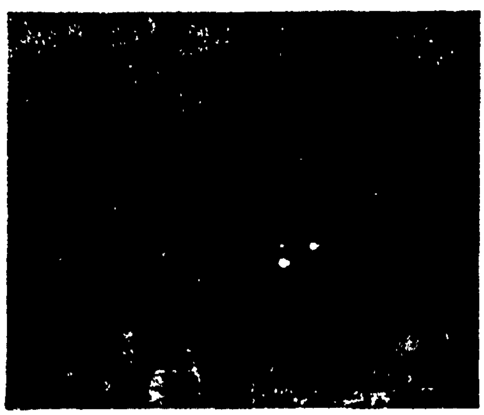
*Crew works in winter dress.*



*Coast Guardsmen set up lights to permit icebreaker to work at night.*



*Navigational aids have been pulled for the winter from constricted channels.*



Mackinaw *works around the clock to free lake carriers.*

Additionally, the cooling of a victim's extremeties may impair his manual dexterity, making it difficult to grasp a life ring or a thrown line. Stress due to cold may also cause coronary occlusions or similar fatalities.

Because research indicates that seamen who fall overboard in winter and spend any time at all in the water are seldom recovered alive, a system to detect these accidents as they occur as well as adequate locating and recovery techniques are critical to the winter navigation effort.

Better designed life craft are also needed in cases where vessel personnel will have time to abandon ship using the life craft. Crews should also be provided routinely with equipment or clothing that provides adequate floatation and thermal protection.

*Vessel master/pilot training assessment*

As a result of ice conditions, navigation poses difficulties both for vessel masters and pilots. Some masters and pilots have not had a great deal of experience operating under ice conditions. This requires a certain amount of training and experience.

*Removal of wrecked or stranded vessels*

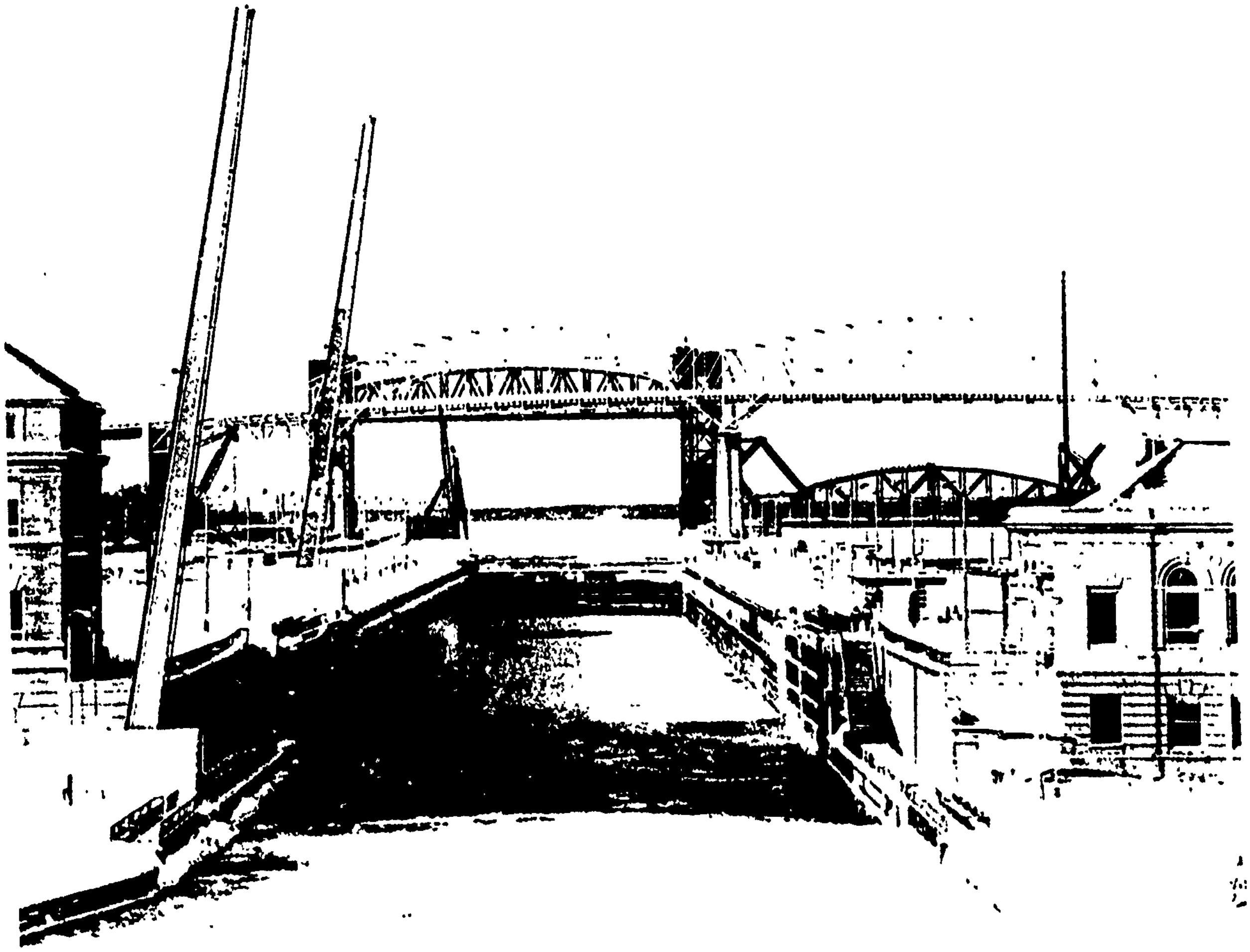
Owners of a stranded vessel generally take prompt action to free it because of the value of the vessel and its cargo. Most stranded vessels are expeditiously removed by owners with the assistance of commercial tugs or lighters. If a stranded vessel is an obstruction to navigation, the owners are required by law to clear the channel as quickly as possible.

During the winter months such a situation is compounded considerably, due to the general inability to control a vessel in heavy ice conditions, particularly in turns between courses and in areas where ice tends to windrow. Other problems occur in open lake situations where large ice fields can trap a vessel and the ice drifts with the wind and current, forcing the vessel aground.

These situations are difficult to anticipate and predict. Each casualty is unique. What may appear to be a relatively simple grounding might result in holing and the subsequent flooding of vessel compartments. When lightering is required, further problems are created in getting a second vessel or a lighter alongside the crippled vessel to accept part of the cargo.

In the extreme case of a vessel sinking in a navigational channel during the winter months, the remedy to the problem becomes much more time consuming and costly. Oil pollution could also delay salvage operations (U.S. Coast Guard is responsible for cleaning up spills).

Should a serious accident occur in certain critical areas of the channel, it might be necessary to suspend navigation through the area until the obstruction can be cleared.



*Lock icing at Soo Locks.*

## Special problems of the rivers

### *International*

The water levels of the Great Lakes are a result of an integration of the hydrologic factors which affect both land and lake surfaces of the Basin as well as the hydraulic characteristics of the connecting channels and the St Lawrence River. These levels are the characteristic which most frequently affect man's use of these waters, since they control shoreline use and navigation and influence the amount of hydro-electric power which can be produced in the connecting channels and the outlet river.

The Treaty of 1909 between Canada and the United States created the International Joint Commission (IJC) and gave it jurisdiction over and authority to act upon matters related to the use or obstruction or diversion of waters of the Great Lakes which would affect the use of these boundary waters by the other nation

There are two locations in the Great Lakes-St. Lawrence Seaway System at which the flow of water can be completely controlled. These are: (1) on the St.

Marys River at Sault Ste. Marie, Michigan, and (2) on the St. Lawrence River above Massena, New York.

Necessary flow changes are determined and carried out by the International Lake Superior Board of Control and International St. Lawrence Board of Control based on studies authorized by the International Joint Commission.

*St. Marys River*

Flow through the St. Marys River is completely controlled in the mile-long reach between the cities of Sault Ste. Marie, Michigan, and Sault Ste. Marie, Ontario. This area originally was a series of rapids which held Lake Superior at an elevation about 21 feet higher than Soo Harbor. A series of four U.S. locks, two U.S. power plants, one Canadian lock and one Canadian power plant utilize an average flow of about 55,000 cubic feet per second. Any excess flow is discharged through a 16 gate control structure located just upstream of the remaining rapids. Under low flow conditions a minimum of ½ gate must remain open to provide flows through the rapids area for environmental reasons.

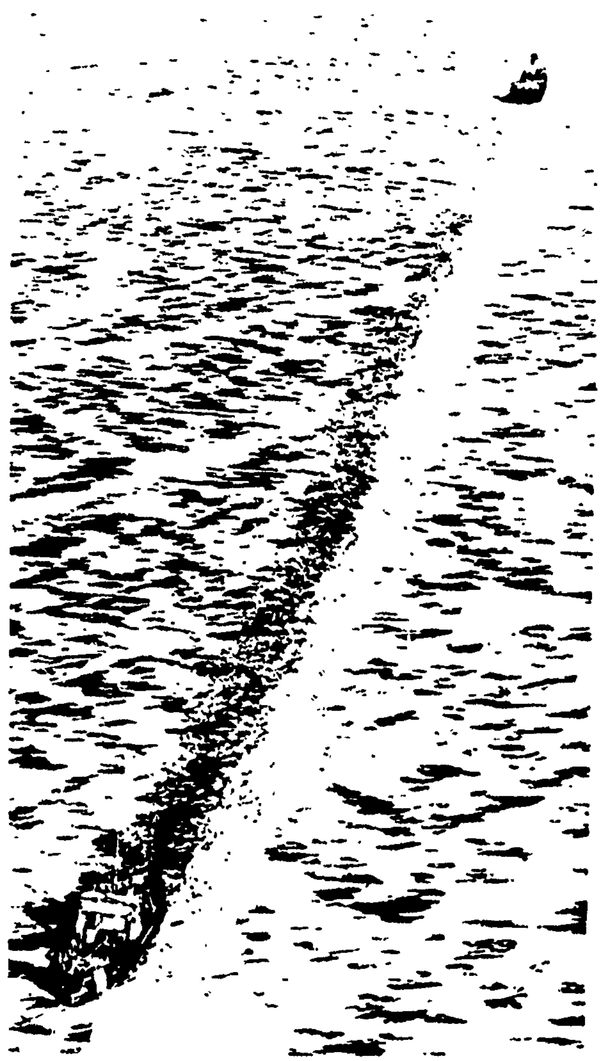
The amount of flow to be allowed is determined monthly by the International Lake Superior Board of Control. The Board directly supervises the operation of the river control works and diversion of flows to power plants.

Winter outflows through control structures are kept within a range of 55,000 to 85,000 cubic feet per second. Experience has shown that winter flows in excess of 85,000 cubic feet per second can result in the breakup of the stable ice cover formed in the Soo Harbor above the Little Rapids Cut. At times this loose ice accumulates and layers in the Cut to create ice jams which hamper Sugar Island ferry operations and winter navigation, and cause water levels to rise upstream in Soo Harbor. In addition to possible flooding, the rising levels downstream of the power plants lower the head for hydro-electric plants, thus affecting power production.

*St. Clair-Lake St. Clair-Detroit River system*

Except for some drifting ice from Lake Huron and shore ice formation, there is little freezing of the St. Clair River. At the head of the river near Port Huron, Michigan, a natural ice bridge forms a relatively stable ice cover and prevents large amounts of ice from entering the river. When this bridge breaks up (either from natural wind and thaw conditions or ship traffic), significant amounts of ice can enter the system.

*Coast Guard creates vessel track for ore carrier.*

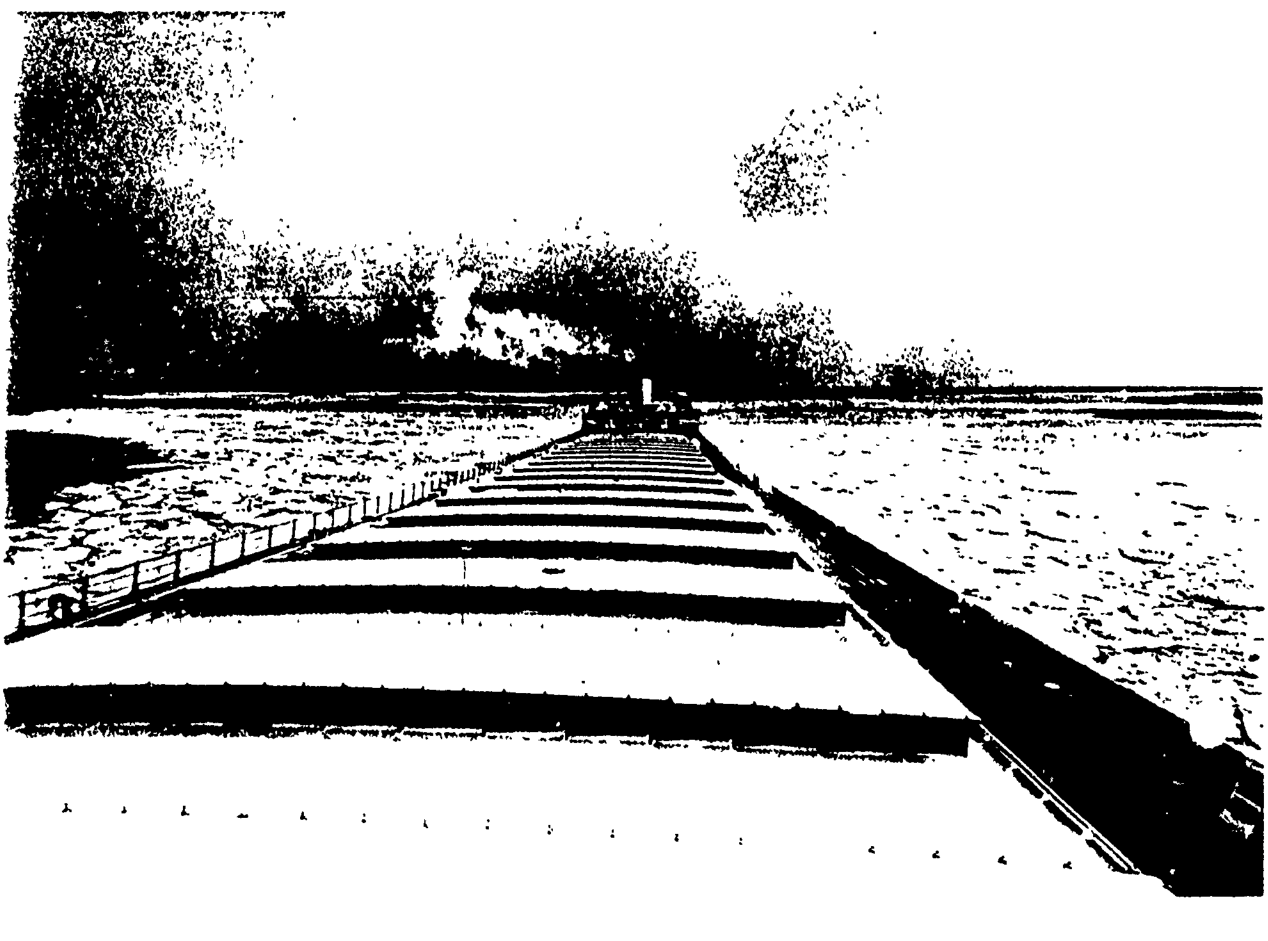


This ice can build up at the mouth of the river where it enters Lake St. Clair, in the vicinity of Russell and Harsens Islands, often jamming the channel and creating a potential for flooding. Heavy ice jams in this location also create problems for the movement of vessel traffic and increase the possibility of damage both to the shore and to shore structures.

Thiee thermal power generating plants are located on the St. Clair River, using river water for cooling purposes. No evidence exists that thermal discharges from these plants have had adverse-to-navigation effects on ice formation in the St. Clair River. It has been shown, however, that as man-made channels are built and deepened, a larger volume of water flows at a faster rate through the river. This decreases ice buildup and lets drift ice flow through the system with less obstructions, thus diminishing flow retardation. This flow retardation has steadily diminished since 1920 mainly as a result of man-made channel activities.

Continued navigation through the ice bridge area at Port Huron may increase ice floes entering the river which would interfere with water intakes. In addition, winter navigation extension may create increased shore and dock damage to the eastern shore of Harsens Island.

A similar problem exists in the Detroit River with the periodic eroding of the ice bridge that forms in Lake St. Clair. Generally, ice floes can pass through the Detroit River into Lake Erie unless easterly winds jam Lake Erie ice into the lower river. Floe ice can back up into the Detroit River to hamper navigation as far



upstream as Detroit. There is concern that winter navigation may cause increased quantities of ice floes to enter the river.

*Niagdra River*

At present, no commercial navigation is anticipated for the Niagara River during the ice season. Ice presents problems, however, to power production on the river.

Since the construction of two hydro-electric power plants by Ontario Hydro and the Power Authority of the State of New York (PASNY) completed in 1956 and 1961 respectively, the flow over Niagara Falls has been partially controlled by a 2,120-foot, gated structure constructed downstream of the intakes. By international treaty, a minimum of 100,000 cfs is required to flow over the Falls during the daylight hours of the tourist season and 50,000 cfs at other times.

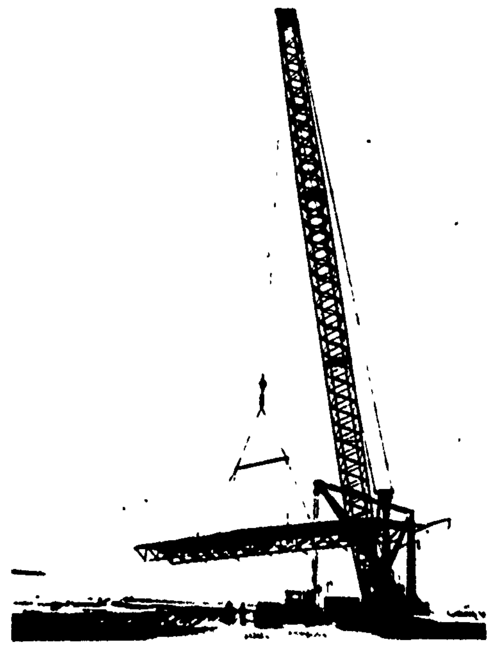
Historically, ice has been a problem in the Niagara River. The Lake Erie ice field, near the entrance to the river, usually arches between the Canadian and the United States shores and restricts movement of lake ice into the river. When the ice is forming, or when the lake is under adverse conditions of wind and temperature, the arch and the ice behind it may break and cause ice to jam in the river above the Falls. The jams can greatly restrict the flow necessary for power production and also cause extensive shoreline damage.

To combat this problem, the two power entities have installed an ice boom at the outlet of Lake Erie every winter since the winter of 1964-65. The boom appears to be effective and has significantly reduced both shore property damage and losses to power production.

Buffalo Harbor, New York, comprised of some 4.5 miles of lakeshore protected by breakwaters, along with sections of the Buffalo River, the Niagara River, and several short ship canals, is normally closed to navigation three to four months each winter.

Because of the prevailing southwesterly winds, and the fact that the capacity of the Niagara River to transport ice is so small in relation to the amount of ice usually present, windrowed ice has traditionally concentrated at the eastern end of Lake Erie during spring breakup in both the pre-boom and post-boom years. The windrowed ice, often several feet thick, usually extends past Buffalo Harbor and into the lake for several miles. Unescorted ship passage through these jams is not possible. Occasionally, even icebreakers have difficulty in moving through this area.

*Winter activity at a St. Lawrence River lock.*



*St. Lawrence River*

The flows in the St. Lawrence River are controlled in three areas. The first area of control is located at the Iroquois Dam and Lock, which extends 1,980 feet between Point Rockway, New York, and Iroquois, Ontario. The dam was designed with the capability to pass or control, if necessary, the full discharge from Lake Ontario. Its gates are used to prevent excessive buildup of water levels in Lake St. Lawrence during periods of strong westerly winds, to minimize adverse currents in the navigation channel of the lower approach to the Iroquois Lock, and to assist in promoting a stable ice cover during periods of ice formation.

The second set of control structures is the Moses-Saunders Power Dam and the Long Sault Dam

located in the Massena, New York-Cornwall, Ontario area, and are used to regulate the outflow from Lake Ontario.

The Long Sault Dam, located below the foot of Long Sault Island, diverts the river flow through the Moses-Saunders Power Plant. Its gates are operated only under high river flow conditions or when flows through the power house need to be restricted for maintenance of generating units. Navigation in this stretch of the river is through the Wiley Dondero Canal and the Eisenhower and Snell Locks.

The third set of control structures is located at the exit of Lake St. Francis where the Coteau Control Dams divert a major portion of the river flow through the Beauharnois Power and Navigation Canal. The Beauharnois Powerhouse, at the outfall of the canal, has a head of 80 feet of water utilized by 36 main generating units with a total capacity of 1,574,000 kilowatts. The remaining flow leaves Lake St. Francis through the Coteau works.

The availability of power in winter depends, essentially, upon the stability of the ice cover. Unstable ice cover can create icejams which can impede the flow of water or block the plant intakes, curtailing power production. When ice is forming in the Beauharnois Canal, Quebec-Hyrdo requests the International St. Lawrence Board of Control to reduce the outflow from Lake Ontario which is accomplished at the Moses-Saunders Power Dam. If the request is approved, Quebec-Hydro follows suit. The River's flow is subsequently increased as ice conditions permit.

Between Ogdensburg and Morrisburg, Ontario-Hydro and PASNY jointly install six ice booms in the International Rapids portion of the River each year near Ogdensburg. The booms assist in the formation and maintenance of a stable ice cover in this area. Two of the booms cross the navigation channel

### The effects of ice on navigation locks

Continued operation of navigation locks under winter conditions involves several problems related to both floating ice and ice that forms on the structural components of navigation locks.

Ice buildup on the mechanical parts of locks can hinder efficient operation of those parts such as lock gates and safety booms. If the ice is allowed to increase to significant proportions, it may cause structural failure of some lock components. The formation of an ice collar on lock walls may impede or prevent the smooth transit of large vessels.

Floating ice above the lock entrances can block gate recesses delaying their opening. Large amounts of ice pushed in ahead of the vessel may prevent the vessel from completely entering the lock, making it necessary to back the vessel out and flush the ice ahead of it. As vessels entering the locks cut through the ice, the ice may become wedged between the vessels and lock walls. This has the potential of jamming the ship tight. If forces on lock wall monoliths increase, the structures can become unstable. This ice jamming is a particular problem with the V-shaped hulls of "salties."

A problem immediately upstream of the locks at Sault Ste. Marie is the shoaling of bottom material above project depth. This results as a consequence of the more powerful propeller wash in winter that occurs when navigating through heavy ice. A problem immediately downstream of the locks is the buildup of loose ice in Soo Harbor as a result of flushing ice downstream through the locks. An ice barrier often results, requiring icebreaking by a large-class icebreaker.

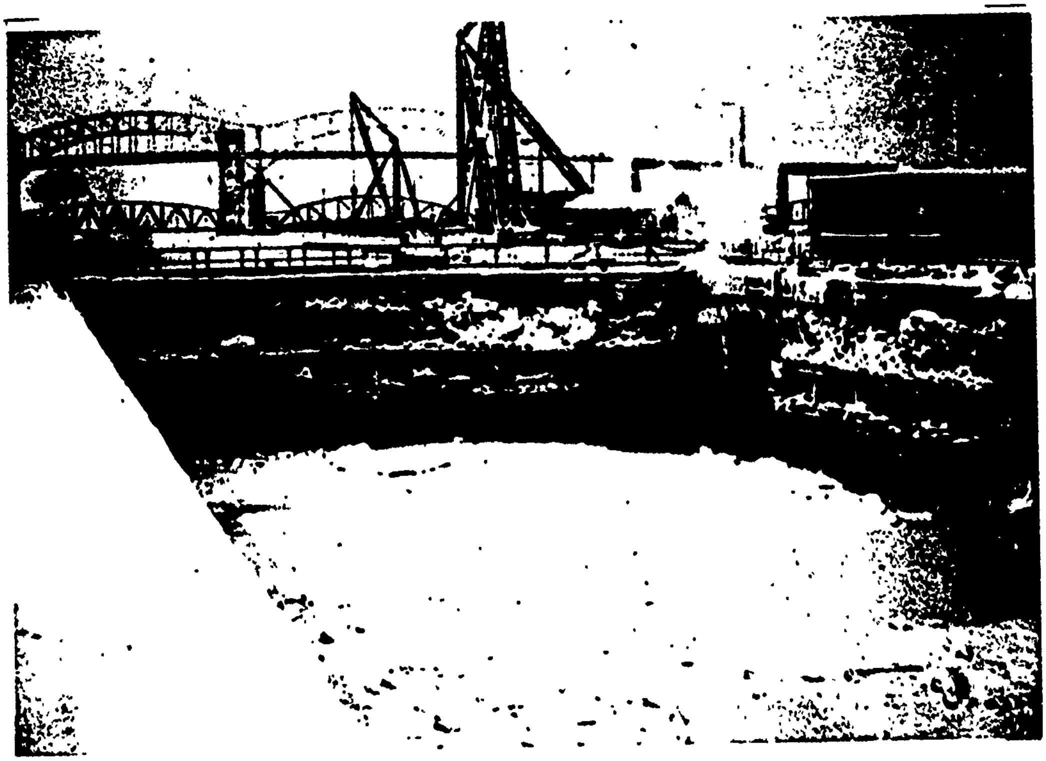
The traditional maintenance period during the winter months will be significantly reduced during an extended navigation season. The reduced working time combined with a higher incidence of wear and tear on the locks due to operations under ice conditions will require a revision of the maintenance schedule.

### Protecting the environment

*Effects on the shoreline and channel bottoms in rivers, harbors and constricted bay areas*

*Erosion and dock damage:* Increased shoreline erosion and damage to shore structures, primarily docks, can result from winter navigation. When a broken ice pack moves into a restricted channel, shore erosion can occur. This erosion is minimized in areas where shallow water exists along shorelines and where water freezes solid to the bottom. Areas of deep nearshore water may be subject to erosion due to the movement of ice floes as well as from the drawdown effects of passing vessels.

Although shore ice may armor the river bank against erosion, major ship disturbances may shift this ice, creating shore damage and exposing it to additional erosion in the spring. During the spring breakup, artificially high water velocities caused by ship passages may also cause a more rapid ice runout than found in normally low river velocities. Shoreline erosion and surface runoff can have an adverse effect



*Ice on lock gate and wall.*

on water quality in that siltation of spawning areas may interfere with fish egg development. Benthic communities may also be disturbed by siltation.

Drift or pack ice, as well as stable ice, can affect shore structures. Pack ice, because of the pressures generated by its movement, has been known to damage structures, particularly those made of wood; stable ice has a tendency to adhere to vertical piles and piers, with fluctuations of water under the ice cover lifting these structures out of position. This is known as ice jacking.

The action of passing ships can also contribute to shore structure damage by intensifying these effects.

*Vibrations:* Adjacent to upper Lake Nicolet, between Frechette Point and Six Mile Point on the St. Marys River, a unique problem sometimes occurs. Local residents have stated that the movement of ships through this reach of the river during ice cover conditions creates vibrations severe enough to cause structural damage to buildings on shore. Although this phenomenon has been reported at several locations within this one area, residents at either end of the reach and at similar areas of the river have not experienced it.

*Bottom scouring:* With the propeller wash of vessels traveling in shallow areas, disturbed bottom sediments, which become suspended in the water, result in increased turbidity and a disruption of benthic communities. Vessel movement through ice requires an increase in the thrust of propellers, creating, a subsequent increase in bottom scouring and its effects.

*Air and water quality*

*Vessel energy usage and air pollution:* Although the Demonstration Program recognized the significant relationship between a season extension and vessel energy usage, along with attendant air pollution potentials, specific studies and experiments have not been conducted with regard to air pollution. Since no site and navigation route, and vessel type and size specific,

system-wide energy usage was demonstrated, only qualitative summarizing statements can be made. The Winter Navigation Board has taken the position that winter navigation will result in a net reduction in energy usage for the nation. There is an additional energy requirement, inseparable from winter navigation, due to the increased level of energy usage for ice breaking, for vessels moving through ice and for the increased vessel traffic. On the balance, studies indicate winter navigation would result in a net reduction of energy usage. This energy savings comes about because of the greater energy efficiency of water transportation as compared to overland modes. Much work needs to be performed to fully document these claims.

*Shore erosion and damage to shore structures was carefully examined during Demonstration Program.*

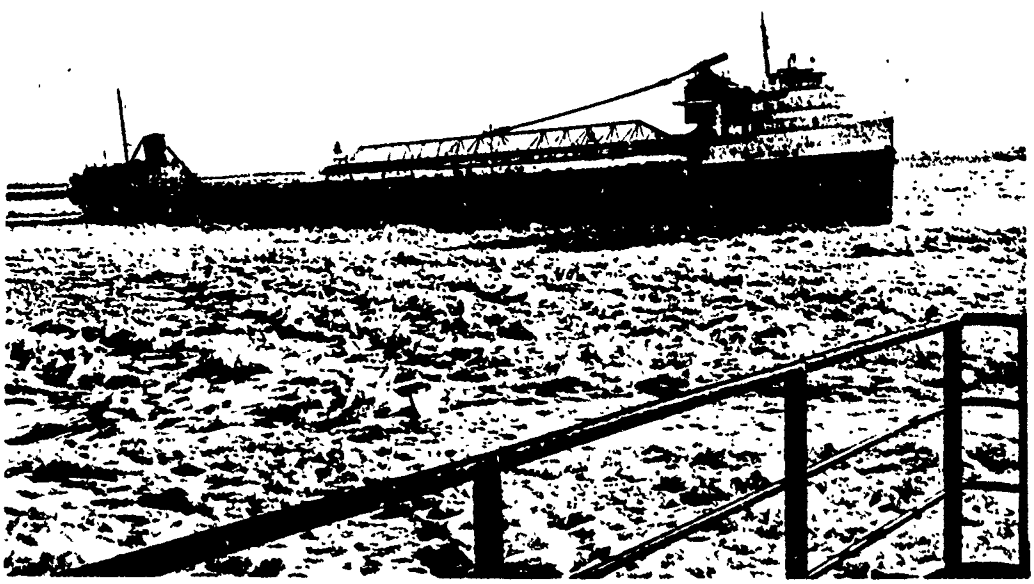
While there appears to be an energy saving and less usage-related air pollution in the National sense there would be an increased energy usage on the system itself. Also some increase of potential air pollution sources is anticipated due to facilities serving winter navigation, such as harbors and locks. This may result in a potential air pollution increase on the system in a qualitative sense. Significant work will need to be executed to define these potential pollution aspects as they relate to the comparatively less sophisticated pollution control facilities of vessels, the increased level of vessel movements, and the applicability and enforceability of air pollution control regulations on international waterways.

*Vessel discharges and regulation:* At present, vessel discharge regulations vary extensively over the Great Lakes and St. Lawrence Seaway System, from state to state, and between Canada and the United States. On the Federal level, the Environmental Protection Agency's (EPA) Standards for secondary effluent are enforced under the Clean Water Act of 1977.

A study of "blackwater" (human body wastes) indicated that no long-term adverse effects were anticipated from additional loadings of treated blackwater wastes from commercial vessels--as a result of an extended navigation season. Although approximately 33% of commercial vessels provide no treatment of blackwater at present, by 1980, the discharge of untreated sewage by commercial vessels will be illegal. These regulations will require Coast Guard certification.

"Greywater" commonly refers to domestic wastewaters generated from galleys, laundries, showers, sinks, and miscellaneous small sources such as drains and drinking fountains located throughout the ship. There are currently no regulations pertaining to greywater unless it is included in the same wastestream as blackwater.

*Turbulence caused by vessel propellers:* The activities of icebreakers and commercial vessels during the Demonstration Program in shallow bays, harbors and connecting channel areas of the Great Lakes System have caused varying degrees of water turbulence, turbidity and bottom erosion. During both



*Ice strengthened* Henry Ford II *moves through ice field.*

*Underway in heavy ice.*

winter and summer months, a resuspension of both polluted and unpolluted bottom materials occurs as a result of this vessel movement, disturbing fish and wildlife habitats as well as water quality.

Although this turbulence has been only partially investigated, it can be concluded from the investigations on sediment transport and shoreline erosion conducted by the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) that the environmental effects of vessel movement are restricted to only the shallower areas of the Great Lakes System. Areas in this category include the St. Marys, St. Clair and Detroit Rivers; small portions of the St. Lawrence River; Lake St. Clair; western Lake Erie; bay areas such as Green Bay, Saginaw Bay and Maumee Bay; and the harbors in the system. With the exception of the harbors, these areas are also the most biologically sensitive and productive in the system.

Water turbulence is caused primarily by icebreaker and vessel propeller wash, by ice chunks driven into the bottom, and by ship-induced waves. Vessel propellers normally generate high velocity currents at or near the bottom that resuspend particulate material within and adjacent to the vessel channels. In ice-covered areas, where more power is required to move a vessel, the area of the bottom disturbance is increased.

Under ice conditions, ship-induced waves and high velocity currents have been found to stir and erode bottom materials outside vessel channels, particularly in shallow areas of connecting channels. These induced waves and currents were found by CRREL to frequently cause normal river currents to take a 360° turn in direction. The velocity of the turning current was also found to be much greater than that of the normal downstream current The rotation of the normal current direction and the great velocity of these redirected currents result in stirring and resuspending bottom substrate materials.

In addition to rotating the direction of the normal current, ship-induced waves also cause a withdrawal and a surge of shoreline waters. In one area of the St. Marys River, the withdrawal and surge of under-ice water has been documented on at least one occasion to have an energy force sufficient to cause a breakup of the shoreline ice cover, forcing fish, aquatic vegetation and bottom material through breaks in the ice cover

In addition to eroding the bottom substrate, this kind of turbulence in the water is capable of causing physical injury to fish, and such turbulence, even of a lesser magnitude, can be expected to render the habitat less suitable The shifting of the bottom substrate as a result of the withdrawing and surging waters also

creates an unstable habitat for benthic communities.

Comprehensive studies determining the extent of impacts of ship-induced turbulence on the fish and benthic communities have not been conducted during the Demonstration Program. Observed effects, however, warrant thorough investigation and the discovery of means to eliminate or minimize the losses.

*Disruption of solid ice cover*

*Recreation:* Recreational activities on the ice-covered connecting channels, harbors and bays of the Great Lakes include ice fishing, snowmobiling, cross-country skiing, snowshoeing and hiking.

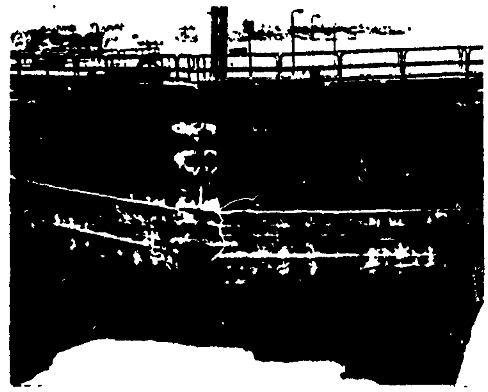
Ice fishing has probably been the most affected by the Navigation Season Extension Demonstration Program because more people participate in this activity than the other sports. In areas such as the St. Marys River, complaints have been received from local citizens claiming that ice fishing has become unsafe as a result of the Demonstration Program. The primary reason they have given is that vessel movement causes the ice cover to crack, break and heave from vessel-induced waves.

It will be important to determine the location of existing and pre-demonstration fishing areas and determine what effect Winter Navigation has on them.

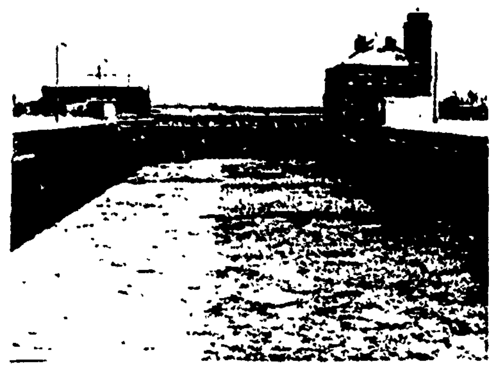
*Commercial fishing:* The Demonstration Program has resulted in reported difficulties with winter commercial fishing activity. The problems have not received in-depth investigation, but Saginaw Bay has been identified as one problem area. Commercial fishing in this bay is reduced because moving ice, caused by a vessel track through the ice cover, often seriously damages gill nets. Additionally, vessel tracks may prevent access to traditional fishing grounds.

*Wildlife migration:* Ice cover over connecting channels, lakes and bay areas provides animals a more available means of moving from one land area to another. This movement, often involving a search for additional food supplies during the winter, offers valuable opportunity for the change of gene strains of island populations. Few studies have been undertaken during the Demonstration Program to identify species that use ice cover for winter movement, the locations, or the extent of this movement, but movement of mammals across the ice has been observed. According to the National Park Service, this is the means by which Isle Royale in Lake Superior may have been colonized by moose and wolves.

It is possible that the St. Marys River ice cover



*Build up of ice on MacArthur Lock gate.*



*Ice in lock at Sault Ste. Marie.*

may be an important link for maintaining balanced animal populations. Species that may be adversely affected by a breaking of the ice cover include the whitetailed deer, moose, bobcat, red fox, coyote, and possibly the endangered grey wolf. Winter movement of these and other animals may occur between the mainlands of Canada and the United States and between the large islands and the mainlands. The presence of a ship track will not prevent this movement but may be a deterring factor.

Waterfowl may be stopped from migrating to more southern ancestral wintering habitats by open water areas created by extended season activities. It will be necessary to determine what effects winter navigation will have on wildlife migration and wintering waterfowl.

*Island transportation access*

*Sugar Island and Little Rapids Cut:* Downstream from the Sault Ste. Marie locks the ice cover in the Soo Harbor and the ice bridge above Little Rapids Cut can break under high wind or thaw conditions and move downstream, sometimes causing ice jams in the lower Little Rapids Cut. The continual movement of vessels during the winter increases the amount of broken ice that could jam in the Little Rapids Cut and subsequently causes disruption to the Sugar Island ferry which provides service to about 450 permanent island residents.

If the ferry track becomes filled with ice or ice builds up in the mainland ferry slip, the ferry is unable to operate. A strong cross current on the island side normally keeps the island slip clear of ice. There is no cross current on the mainland side and drift ice entering the slip can make landing difficult or impossible.

The Sugar Island ferry initially had limited ice operating capabilities. Its ability to operate in ice conditions was subsequently improved for operation during the Demonstration Program.

*Industrial stockpiling — costly alternative to water transportation.*

*Neebish Island and West Neebish Navigation Channel:* The Neebish Island ferry currently stops operating when ice begins to develop. Accessability to the mainland for the island's 30 to 50 winter residents resumes when the ice becomes thick enough to support foot or snowmobile traffic. At this time, downbound vessel traffic is directed to the Middle Neebish Channel and does not disrupt normal access to the island.

If the West Neebish Channel is used for future winter navigation, the island will be isolated from the mainland; access problems will be created similar to those experienced by the Sugar Island residents. (A particular problem in the Middle and West Neebish Channel is that neither channel can accommodate two way traffic without a traffic control mechanism During the normal navigation season, the Middle Neebish is used as the upbound channel and the West Neebish is

used as the downbound channel.)

*Lime Island:* With the advent of winter navigation, ship tracks cut through the stable ice cover between inhabited Lime Island and the Michigan mainland, destroying the ice cover access which was historically used by the island's winter population of about 10 adults. The residents of Lime Island are employed by a private company which is located on, and also owns, the island.

*Drummond Island and DeTour Passage:* Year-round access for Drummond Island's 600 permanent residents is provided by a ferry across the mile-wide DeTour Passage. Historically, ferry operations have been hampered by ice blown north from Lake Huron. The ice jams against the stable ice bridge which normally forms across the Passage upstream of the ferry crossing in the vicinity of Pipe Island. Northerly winds tend to clear the passage south of this ice bridge, but frequently loose ice is blown along the shoreline at DeTour and or Drummond Island. The ice tends to compact in the ferry landing slip and hampers ferry docking procedures.

Commercial navigation through the solid ice field in DeTour Passage has not affected its overall stability. Some loose ice dislodged at the edge of the ice bridge at the navigation track may drift away under northerly winds reportedly hampering ferry operations, but the large areas of ice are not affected by the relatively narrow navigation track.

Winter navigation during the Demonstration Program has interfered with an alternative mode of transportation to Drummond Island: snowmobiles can no longer safely utilize the stable ice bridge north of the ferry crossing because of the vessel track which is reopened with each ship passage.

*Historical and cultural resources*

Cultural resources include almost anything that affects the daily living patterns of people in a given area. They can include items such as land use; number and location of public, commercial and individual facilities; and recreational habits and sites used by local inhabitants. Historical resources consist primarily of buildings or sites relating to events important to an area's past, or representative of past living modes.

Negative impacts on these kinds of resources may result from changing ice forces, from potential changed water levels caused by ice boom modifications, and from the results of ship transits through ice. These negative impacts include both the possibility of increased shore erosion and potential damage to structures located in or along the water. As well, any activity change from the norm (such as the disruption of recreational fishing) could be considered a negative effect on an area's cultural resource.

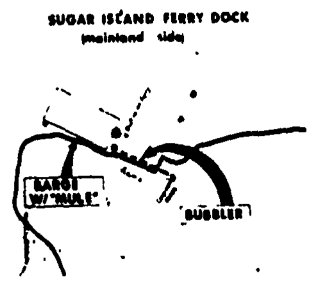



*Diagram shows Sugar Island ice control activity.*

*Bubbler/flusher system at work at Sugar Island Ferry Dock.*

To minimize any possible negative effect on these resources, a complete inventory is necessary to identify existing resources and to develop plans which will minimize the negative impacts on them, should they occur. (Erosion and structural damage control measures are discussed later in this report.)

*Local climatology*

*Buffalo, New York:* Each winter since the winter of 1964-1965, an ice boom has been placed at the mouth of Lake Erie above its outlet into the Niagara River. The boom is installed under International Joint Commission authority by the Power Authority of the State of New York and Ontario Hydro. The purpose of the boom is to enhance the formation of a stable ice cover in early winter (which occurs naturally at the boom site anyway) and to dampen the effects of the late winter wind-generated ice runs. This mitigates ice control problems at the downstream intakes of the power entities. Such problems in pre-boom years led to serious ice jams in the river, resulting in reduced power diversions and the ensuing increased energy losses. Heavy ice runs also caused extensive damage to shoreline property along the Niagara River.

Studies conducted throughout the fifteen-year post-boom period show that the ice carrying capacity of the Niagara River is virtually insignificant when compared to the natural rate of dissipation of Lake Erie ice by melting in place, and to the enormous amounts of ice present on the lake (often ten thousand square miles). However, small amounts of ice, in terms of the total amount on the lake, can have disastrous effects on the Niagara River.

The installation of an ice boom, at the head of the Niagara River near Buffalo Harbor, is felt by some, to prolong the period of ice cover. Notably, in this area, the U.S. Lake Carriers' Association felt that the start of the navigation season was unnecessarily delayed due to this effect. The Council of the town of Fort Erie, Canada, also felt that the ice field restricted recreational sports and deterred the flow of tourist dollars into that area.

Although it has been shown that the water temperature regimes have been lower during April in the post-boom years, there has been no evidence of any effect of the boom on local climatology, navigation, or recreation by any of the many technical studies performed to date by the IJC, its cooperating agencies or independent investigators.

The theory has been proposed that the boom may, in fact, reduce the severity of the Lake Erie ice cover since a stable ice cover is less subject to windrowing and dense packing. This theory has not been substantiated by factual data, nor have any claims that the boom extends the ice season.

The boom does not intersect any commercial navigation routes, and, therefore, has no known effect on existing commercial navigation.

*Vessel tracks at St. Marys River.*

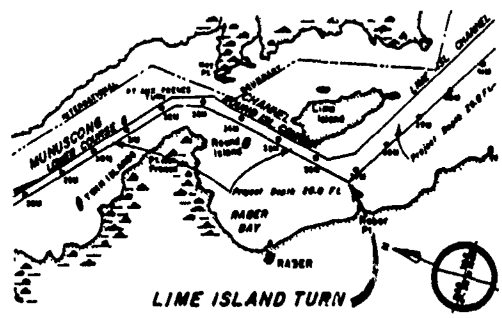



*Diagram shows Lime Island Turn.*

*Great Lakes/Seaway Region in general:* Atmospheric temperature inversions, a common phenomenon during the spring warmup period, occurs over the Great Lakes region. This inversion is created when warm air masses pass over cold lake surfaces and become chilled. A result of a temperature inversion is the development of an interface separating the upper warm air mass from the lower colder air mass. As a result, gaseous discharges into the bottom layer become trapped and air quality deteriorates in regions having sufficient gaseous discharges, if the inversion phenomenon extends over a prolonged period. Any activity which tends to upset normal heat transfers between the Lakes and the atmosphere could cause a change in local microclimates.

*Working in winter*

*Rescheduling vacation time:* Four occupational groups have been identified as being directly affected by winter navigation activities: vessel, terminal, lock and pilot personnel.

Vessel personnel include about 5,000 people at the peak of the shipping season. These employees are assigned to vessels operating with about 30 men per ship.

U.S. and Canadian piloting personnel throughout the System number about 155, and maintain a seasonal lifestyle of spring, summer and fall employment, with the winter months open for vacation or recreational activities.

With winter navigation, seasonal employment for these groups would change to year-round employment.

Terminal and dock personnel are usually employed year-round and, although season extension would not materially affect their work, their specific duties would change with a navigation extension.

There are about 4,000 persons employed in terminals at the peak of the season, and another 350 employed at the Sault Ste. Marie and St. Lawrence Seaway locks. Changes, both in the work activities and vacation schedules, would emerge from an extended season effort.

*Working in cold weather environments:* Winter weather, of course, poses certain problems for people working in the winter months. Productivity is obviously affected due to time required for snow removal, and the movement of bulk cargo can create handling problems should they freeze into large chunks.

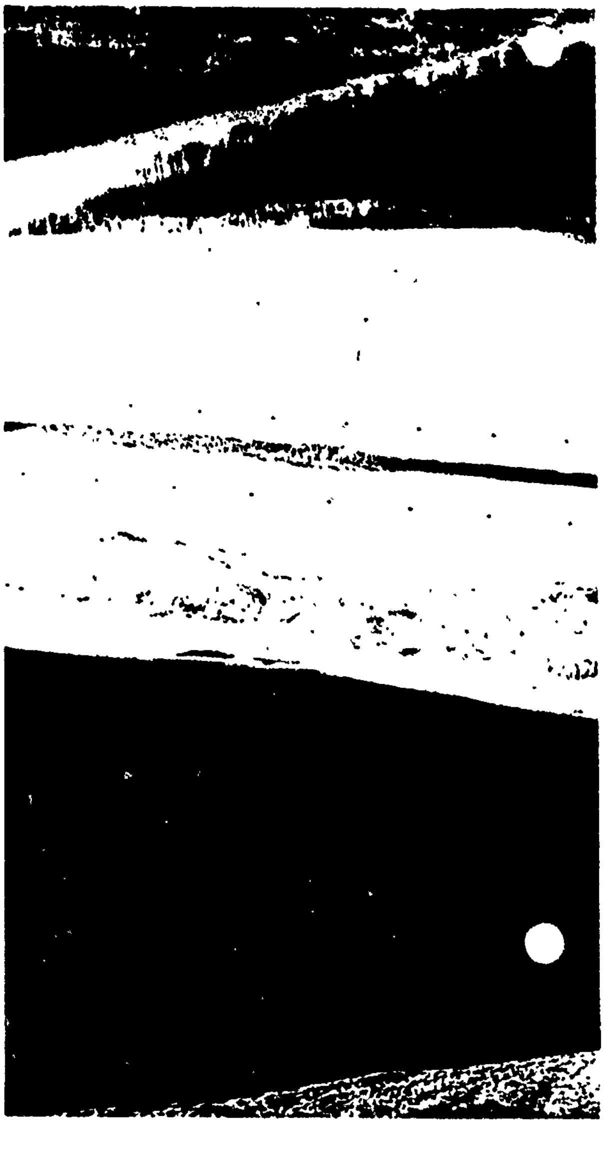
Equipment used in winter requires longer start-up periods. Year-round use also eliminates overhaul time, and may necessitate the purchase of additional equipment

The safety and dress of workers in winter conditions is also a major item of concern.

*Moving oil and hazardous material during winter*

Heating oil, gasoline and benzine are generally the only hazardous materials moved in quantity on the

*Ice boom constructed with an open water navigation channel through the ice cover.*



Great Lakes during the winter months. Few, if any, spills occur. The Coast Guard has indicated that winter navigation does not include an inherently higher risk of spillage. Historically, most spills are related to wave damage and grounding. Ice cover significantly reduces the potential for these types of incidents.

Consistent concern has been expressed by some local residents as to the ability of the Government to adequately contain and clean up such spills before irreversible damage occurs in the environment.

The Department of the Interior and Environmental Protection Agency have concluded that present day technology to clean up spills in ice covered fluvial waters of the connecting channels is inadequate to protect fish and wildlife resources and their habitats.

## Defining costs and benefits

As part of the overall Great Lakes and St. Lawrence Seaway Navigation Season Extension Survey Study, problems have been identified and solutions developed and tested under the Demonstration Program in order to show that winter navigation is possible. Many of the Demonstration Program's activities were conducted in one location which is representative of several areas. Then, too, many solutions to problems required the development of new hardware and techniques at costs considerably greater than those for standard, commercially available material, if they could be used.

It becomes apparent, therefore, that costs in a Demonstration Program may not be representative of those occurring in a normal system-wide program. At the same time, the use of experimental costs prohibit the establishment of an accurate cost-to-benefit ratio for the Demonstration Program itself. Costs of each demonstration project are accurately recorded for consideration in the overall feasibility study

## Canadian co-participation

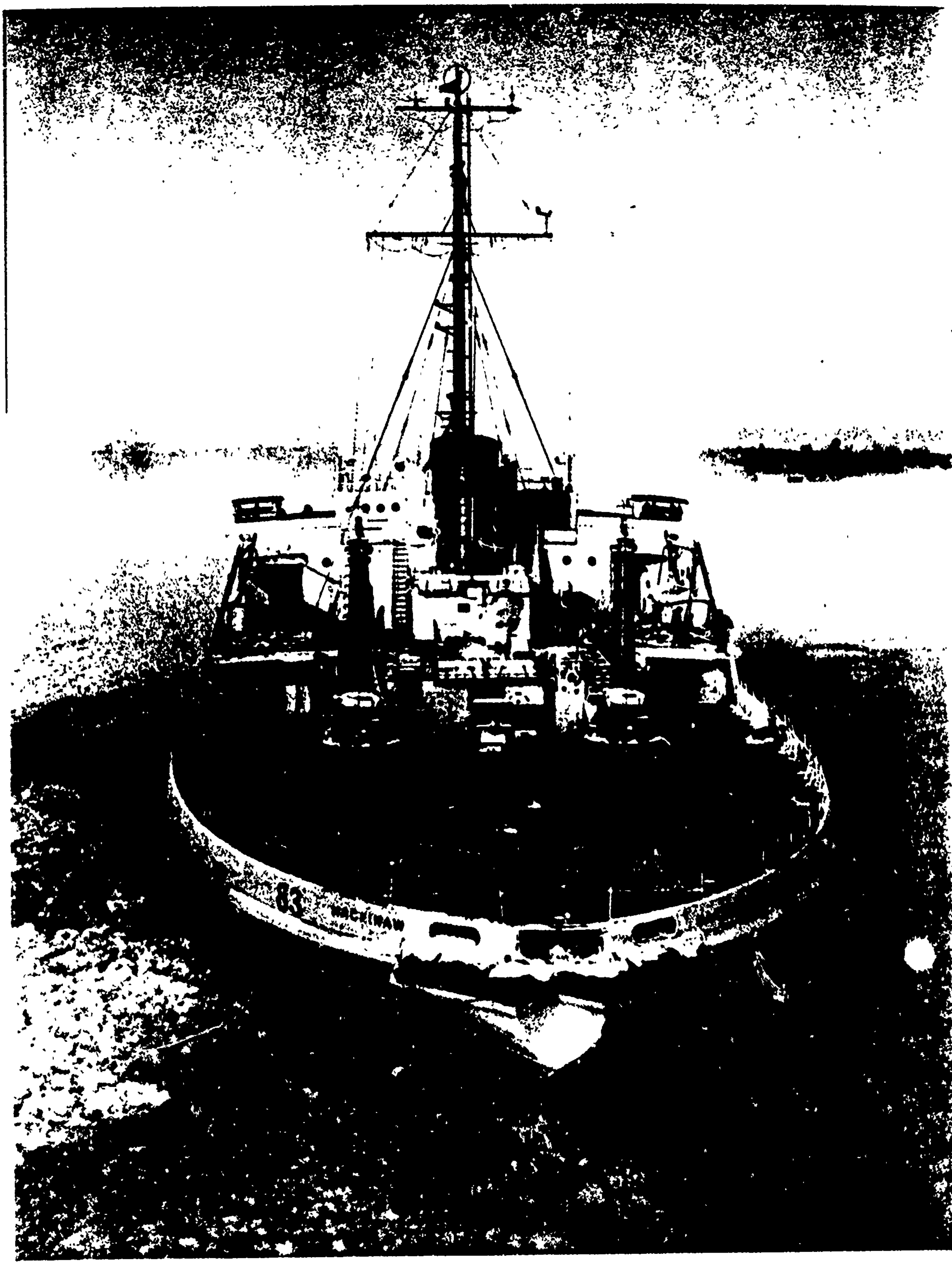
For any system-wide season extension program to become a reality, Canadian co-participation is vital. In addition to sharing ownership of the system, the major portion of the St. Lawrence River, the system's link to the world's oceans, is within Canadian boundaries. Its Seaway facilities are under the jurisdiction of the St. Lawrence Seaway Authority of Canada.

The system below Montreal currently enjoys year-round navigation. Sharing such a vast resource, Canada has an obviously large stake in any extended navigation season, and especially as it relates to the movement of goods to and from foreign countries.

Cooperative relationships with Canada are critical to the success of the program.

## Public involvement

An important ingredient of the Demonstration Program has been the public involvement program, in which various publics have been informed about the first actions and results of past studies relating to the winter navigation efforts. Comments and suggestions were and will be continually encouraged from groups and individuals in order to allow the Winter Navigation Board to gain the widest input possible and to direct activities acceptable to all levels within the constraints of the Program. This type of public input served to focus on many of the problems facing the program such as shore erosion and structure damage, island access difficulties, and the need for comprehensive environmental studies.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*After view of the* Mackinaw.

# III. ACTIVITIES TO DATE

## Assisting vessels through ice

*Icebreaker support*

One of the primary activities pursued by the Great Lakes Demonstration Program was the overall objective of safe and efficient movement of vessels through ice-covered waters. The major responsibility for this effort fell to the U.S. Coast Guard with its icebreaking activities.

*Coast Guard vessel fleet*

In the Great Lakes-St. Lawrence Seaway System two large icebreakers are used to facilitate extended season vessel movement in ice-covered waters. In addition to these two vessels, one of which is the Great Lakes icebreaker *Mackinaw*, a number of smaller cutters are normally employed in rivers and narrow channels to maintain traffic flow.

During the demonstration effort, Canadian icebreaking vessel activities were coordinated with those of the U.S. Coast Guard. Section 2 of Title XIV, U.S. Code was amended by PL 93-519 to authorize such cooperative icebreaking activities on a seasonal basis.

*Preventive icebreaking*

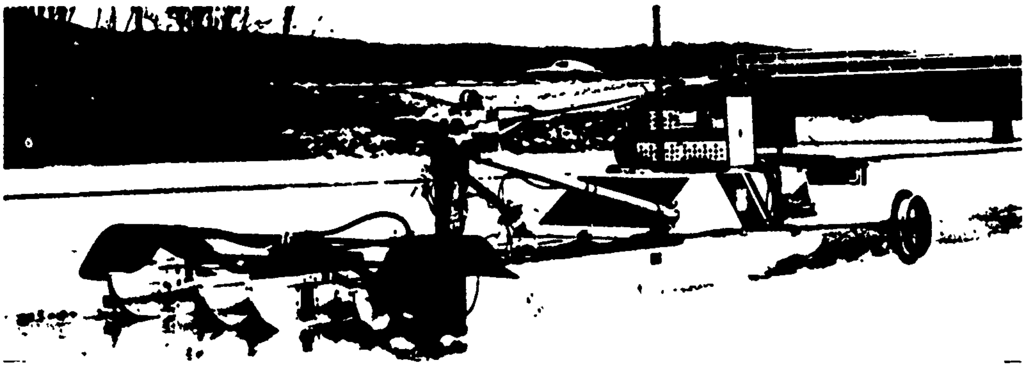
Preventive icebreaking has proved to be an excellent alternative to single ship escort in many areas of the Great Lakes. This activity involves opening and then maintaining tracks through the ice for large vessels to follow to their destinations unescorted.

*Convoy travel*

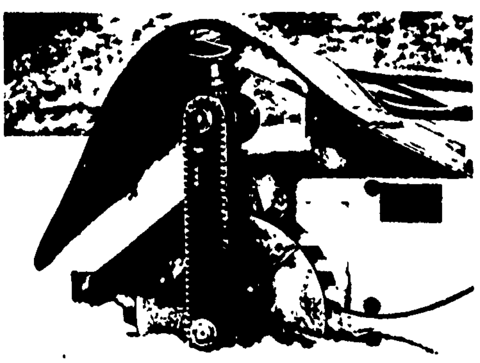
During the latter years of the Demonstration Program, the use of convoys have proved to be effective in reducing the work load of the icebreaker fleet. In this case, ships are assembled at a given point and are assisted to their common regional destinations by an icebreaker.

*Joint U.S. Coast Guard-Canadian Coast Guard Guide*

To facilitate the transmittal of information on icebreaking techniques and policy utilized during the Demonstration Program period, a joint U.S. and Canadian icebreaking guide was developed and distributed to all U.S. and Canadian shipping companies each year of the program.



Scale model mechanical ice cutter.



Ice saw.

*Non-conventional icebreaking*

Several methods of icebreaking were tested during the period covered by the Demonstration Program. The tests were conducted in various locations both within and outside of the Great Lakes Basin. Not all tests were funded directly under the Demonstration Program. Information obtained from these tests have indicated that none are universally implementable under conditions found on the Great Lakes and their connecting channels.

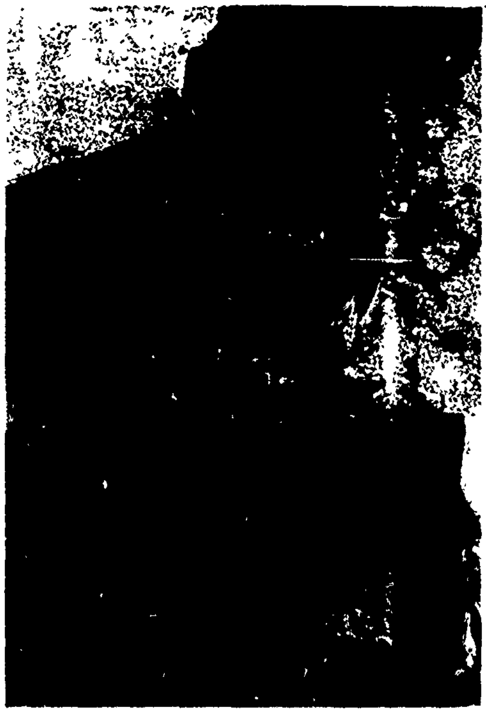
A submerged icecracking engine was tested on Muskegon Lake near Muskegon, Michigan. This device breaks up ice by periodic sudden release of high pressure combustion gases underneath the ice. An operating form of this device would be ship-mounted for navigation channel clearance in lakes and rivers. Tests indicated that this device could clear a channel 40 feet wide through ice two feet thick at a rate of five MPH. A drawback for this type of icebreaking device is that it requires a substantial increase in the power supply of the accompanying vessel.

Experiments were conducted to determine the power requirements of cutting ice with high pressure water jets. Tests were conducted near Houghton, Michigan, under conditions that yielded ice thicknesses of at least two feet. It was determined that this form of icebreaking was not feasible because it required excessive power plants and the current state-of-the-art for necessary high pressure waterjet equipment was not reliable.

The operation of a mechanical ice cutter (MIC) was also investigated. The MIC consists of circular saws mounted on the forward bow of a barge. When the barge is pushed into the ice field, two longitudinal cuts are made. Once cut, the sides break, bending under the cutter barge, and are deflected laterally under the adjacent ice sheet by a skeg, mounted beneath the barge. It was thought that the MIC would leave in its wake an ice free channel. But it was found that the cleared channel would refreeze and with each vessel passing a new frozen cover with significant brash content would occur. It was also found that breakage of adjacent ice cover by vessel waves added to the brash content in the channel.

*Air cushioned vehicles*

During the winter of 1975-76 Transport Canada conducted tests of a new icebreaking method at Thunder Bay, Ontario, using an air cushion vehicle, *Iceater I*. This vehicle is a modified ACT 100 hovercraft with a 14 foot "V" notch cut into its hull to accom-

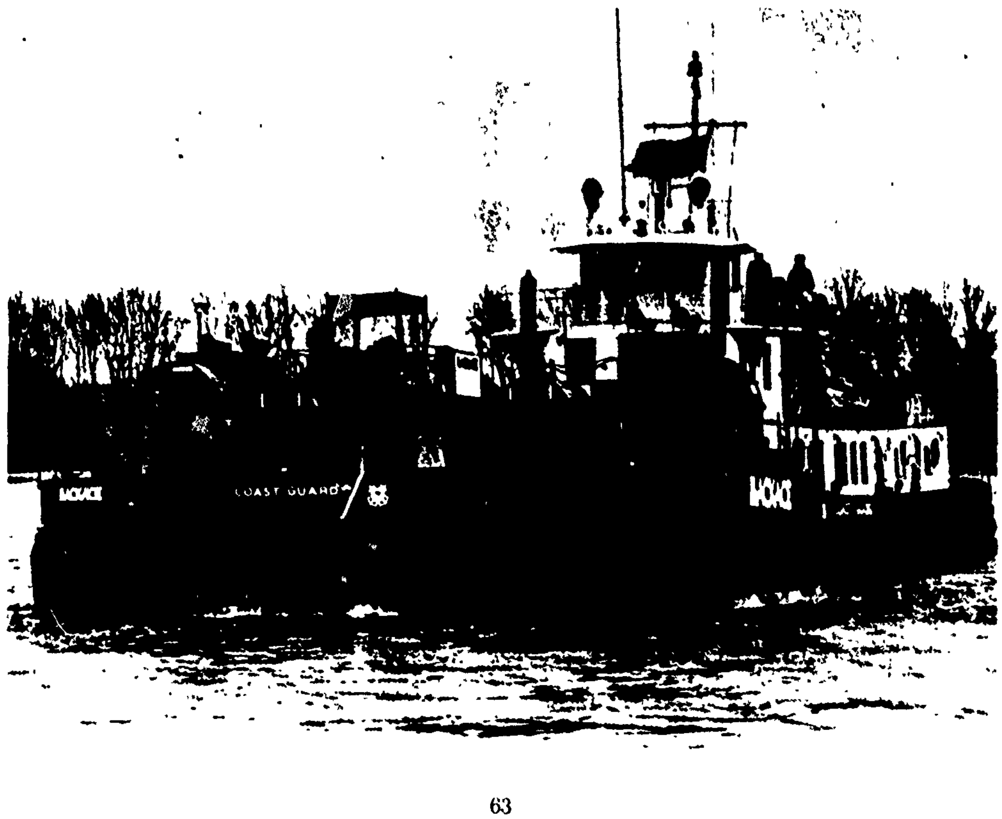


*Canadian icebreaker pushes air cushion vehicle unit during Lake Superior tests.*

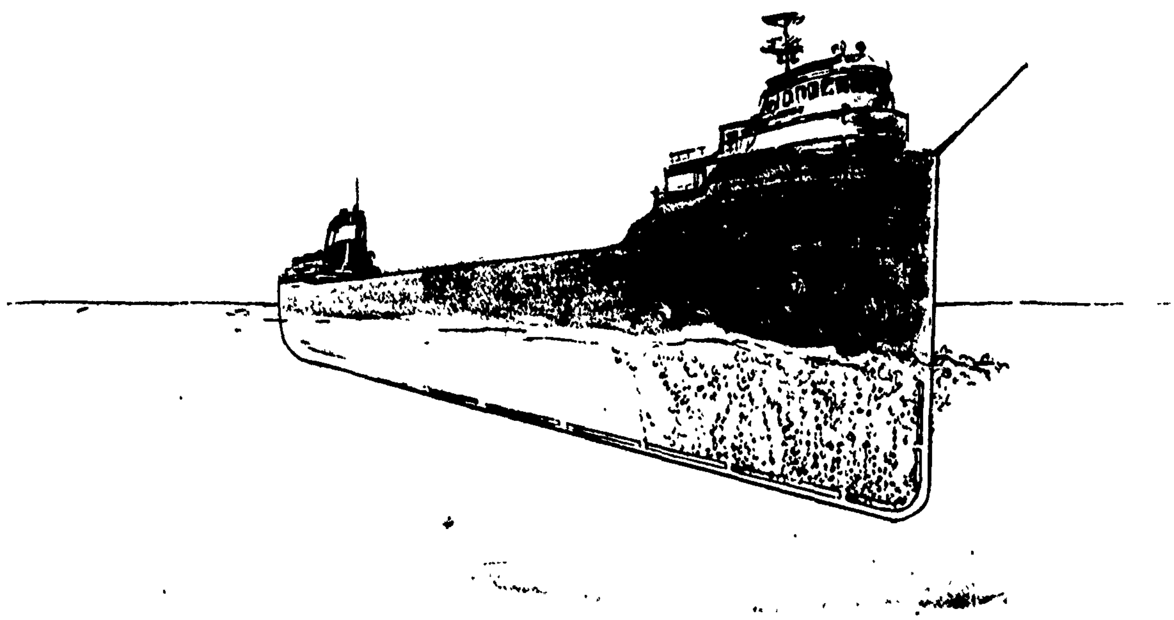
modate the bow of a powered vessel. The U.S. Coast Guard performed tests during the winter of 1977-78 using air cushioned vehicles as icebreakers on the Illinois and Mississippi Rivers. Vehicles tested included both bow mounted and self propelled vehicles. All vehicles tested were successful in varying degrees in use as icebreakers.

While all these tests showed the various devices are feasible as icebreaking methods, available technology does not necessarily make them practicable. Additionally, test locations do not ensure that the results are universally applicable for use under conditions found on the Great Lakes and their connecting channels.

*The* Mackace, *a bow mounted air cushion vehicle.*



*Artist's interpretation of air bubbler system on ship hull.*

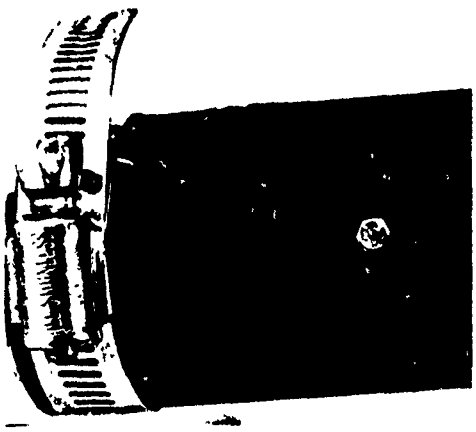


*Air bubbler system on vessel hulls to ease transit*

An air coating system on a vessel's hull was designed to produce and direct a uniform coating of air around the vessel's hull, thereby reducing the amount of friction a vessel would encounter while moving through ice fields. The system consisted of a series of manifolds located external to the ship's hull, with each mainfold connected to an air supply line The rapid expelling of large quantities of air through the small holes in the mainfold caused an upswelling of water to accompany the air. This combination of air-water mixture provided a lubricating film between the ice and the hull. Gauges were placed on the hull of the testing vessel to measure forces caused by movement through ice. Tests demonstrated that the test vessel did show reductions in friction while moving through ice. They also indicated the practicability of designing air manifolds to allow a uniform air coating to be obtained at various drafts and trim conditions. It has not been determined whether or not such a system is an economical solution to this problem.

## *Air bubbler systems to suppress ice in channels*

An air bubbler system produces rising air bubbles which move the slightly warmer bottom water to the surface, where it melts ice or reduces ice thickness, easing a ship's passage. An onshore air compressor feeds air through a supply line to a flexible perforated bubbler pipe anchored along the channel bottom, where its small holes — 10-15 feet apart — cause a bubble stream to move continuously upward, creating a current to the surface. The bubbler pipe floats above the contour of the bottom, supported by ropes secured to concrete block anchors.

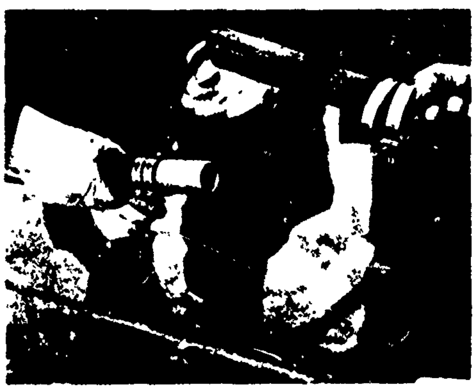


*Section of bubbler pipes shows small hole through which compressed air is released.*

Bubbler systems were tested for three winters (1972-75) at the Duluth-Superior Harbor to determine the effectiveness of the system over various configurations and locations within the harbor. During FY 73 a loop bubbler system was installed on the west side of the Superior entry to the harbor. The site was chosen because late shipments of ore were scheduled to be made that winter to nearby docks. The bubbler system was intended to furnish information on the problems involved in installation and data on the effectiveness of the system in facilitating movement into and out of the docks. Environmental effects resulting from operation of the system were monitored prior to installation, during operation, and after shutdown.

Another bubbler system was installed at the Duluth-Superior Harbor in and adjacent to Howards Bay to obtain additional information on the costs and problems involved in installation and maintenance of bubbler systems and to further evaluate its effectiveness in facilitating vessel movements in harbors. This site was chosen because two vessels were to arrive at nearby shipyards located within Howards Bay during early February 1974 for structure modifications. Again, the environmental effects were monitored by a consultant. During operation, the system was damaged twice by passing ships. Both times, after the system was repaired and operation resumed, the ice was dissipated rapidly.

The bubbler system in the Howards Bay area of Duluth-Superior Harbor was again used during the 1974-75 winter season for the purpose of examining the impact of such a system on water quality.



*Air bubbler pipe laying operation.*

The bubbler system at the Superior entrance to the Duluth-Superior Harbor extended shipping at the docks until 1 January 1973. A severe early winter caused a heavy buildup of ice at the docks, cutting short the scheduled extension of ore shipments by about one week. The vessels had no difficulty in maneuvering in the bubbler area.

The bubbler system at the Howards Bay location was operated until 19 February 1974. The system performed well during the test period, succeeding in keeping an area 25 to 40 feet wide clear of ice over the length of the bubbler and with greatly reduced ice thickness extending an additional 20 feet on either side.

Vessel track

The bubbler system also proved to be environmentally acceptable with no serious adverse effects observed during three years of study. The system appears to be practical and suitable for use over a wide variety of applications and locations.

In the St. Marys River, at the Lime Island Turn, a bubbler system was used in the winter of 1972-73 and again in 1973-74. This location was selected because ships experienced unusual difficulty in negotiating the sharp 70° turn in a stable ice field that produced as much as three feet of ice. The water depth was about 55 feet and current velocity was relatively low (less than one-half foot per second). This test used a 5,000-foot supply line from the Island connected to a 3,000-foot bubbler pipe located on the channel bottom.

Vessel track is apparent in this St. Marys River photo.

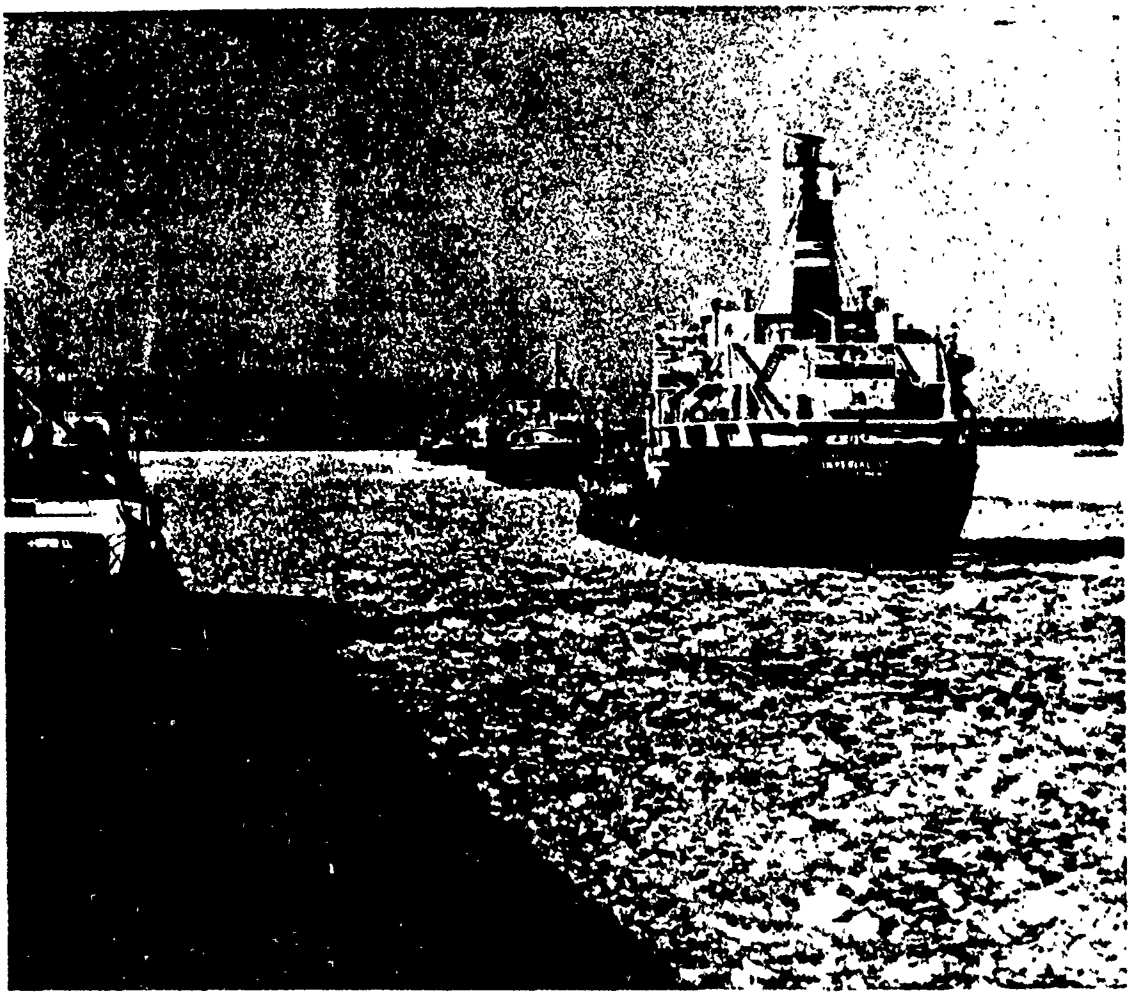
The Lime Island Turn bubbler installation performed well. Ice thickness was negligible directly over the diffuser pipe. The installation significantly aided vessel passage through the Turn, although it was learned that ships had to pass directly over the bubbler center line in order to achieve maximum benefit.

Vessel masters traversing the St. Marys River during the extended navigation season reported that as a result of the bubbler system they were able to negotiate Lime Island Turn without difficulty. They suggested that the bubbler line be lengthened to include more of the turn, and some expressed the opinion that there was some decrease in ice thickness downstream from the turn because of the bubbler operations.

*Thermal ice suppression*

A test was devised during the Demonstration Program to investigate the use of thermal discharge from industry and power production in various locations around the Great Lakes as a means of facilitating winter shipping. A thermal suppression system is very similar to an air bubbler system in that warm effluent water is released through a diffuser pipe

*View of convoy.*



to reduce ice thickness or to prevent ice formation in a navigable waterway.

Through the end of FY 75, efforts were made toward site selection, a feasibility study, the collection of environmental baseline data for several years prior to testing, the design of a pilot test facility, and the purchase of equipment. A number of locations were considered. Saginaw Bay, at the mouth of the Saginaw River in Lake Huron, was finally selected as the best site to study the thermal ice suppression process. Equipment was installed and tested in FY 76.

The thermal ice suppression demonstration was conducted using heated effluent from a power plant located near the test site. A feeder pipe was installed to the navigation channel and a diffuser pipe 800 feet long was laid along the channel edge.

The heated effluent was discharged through a series of nozzles positioned at angles of 0° to 45° and 90° to the channel bottom. Test data was collected throughout the winter to determine the horizontal extent of the effects of the heated water, its effectiveness and its environmental impacts. Substantial ice melt, which was anticipated, did not occur. The thermal plume from the horizontal and 45° diffuser nozzles did

*Gathering ice information.*

not melt surface ice However, the verticle jets did produce open water areas The potential of combining an air bubbler system with warm water discharges was favorably discussed but no studies were performed

## Navigation aids, devices and systems

### *Prototype ice buoy tests*

A regional deterrent to winter navigation in the confined waters of the Great Lakes-St. Lawrence Seaway System is the removal of the conventional buoys by the Coast Guard as ice begins to form These buoys are removed to prevent their being moved off station, or capsized by ice

Based upon admittedly limited experience, the Coast Guard, in 1972, designed six buoys to withstand the rigors of the ice environment. Various sizes were designed to ascertain cost ratios, ice accumulation on superstructures and handling capability. Of the six, two were stock items from the Coast Guard's existing inventory of ocean buoys. These were modified by removing open cage ladder-style superstructures and installing cylindrical 12 inch diameter tubes to support beacons. This modification reduced the affected area of ice accumulation.

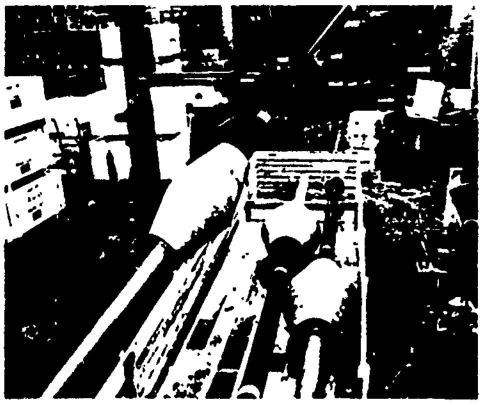
One of the buoys was 9 feet in diameter and 20 feet long, with a conical base. Under high forces, the sloped edge of the base could assist the buoy to ride up to the surface of the ice, reducing the strain on the anchor. The second was a standard cylindrical buoy 9 feet by 32 feet.

A Discus buoy was designed and constructed in an octagonal shape deployed in the St. Marys River at the Lime Island Turn. The largest buoy tested, the Discus was 16 feet in diameter, but with a shallow draft and with sloping sides so that it too would ride up on the ice surface under heavy pressure.

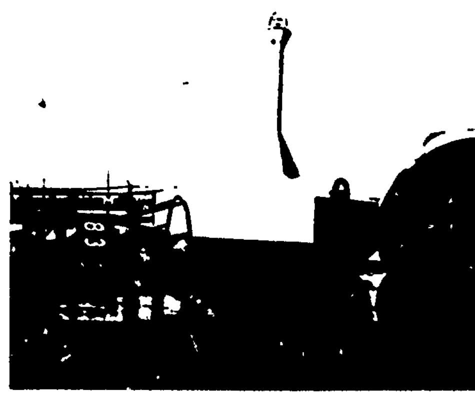
The three large buoys were made with a special anchor system comprised of a high holding power "Stato" anchor, which was capable of producing a holding power to weight ratio of 10:1 and possibly 20:1. With an anchor weight of 9,000 pounds, the holding power could reach 180,000 pounds in the river bottom soils commonly found in the Great Lakes areas. In each mooring chain, self-recording tensiometers were installed to provide data which would determine the ice forces experienced and provide a comparison between different buoy hulls, shapes and sizes.

Three smaller buoys, 5 feet in diameter and 18 feet long, were also tested under ice conditions in the Detroit and St. Clair Rivers, where large sheets of ice do not frequently occur This would reduce the ice forces on moorings. Instability due to ice accumulation on superstructures was a common problem in these areas, so the modification in the 5-foot by 18-foot buoys attempted to maintain the buoys in an erect position, despite the ice formation.

Additional testing of ice buoys continued in FY 75, with the high hopes that "Stato" anchors and some design modifications of ice buoys would solve problems. Ice accumulation on the top of buoys resulted in the buoy becoming top heavy and turning over, displacing the light from the mariner's plane of eye and damaging the lantern. Also, shifting ice floes in the channel resulted in displacement of buoys, taking them from their charted positions. The tests did not confirm that the revised design solved these problems.



*Experimental ice buoys brought to Great Lakes from Baltic for tests.*



*Octagonal ice buoy.*

User reports indicated that the experimental buoys were generally effective--they maintained their position in ice, were highly detectable on ship radar, readily detectable visually and were a valuable aid to the shipmaster in planning his approach to a turn in the channel. Although the ice conditions were relatively mild during the testing period, the results of these tests indicate that it is possible to design and deploy ice buoys for year-round navigation.

While useful in certain areas from the mariner's standpoint, specific lighted ice buoys proved to be less reliable. Generally, unlighted ice buoys showed more promise, and it is expected that there would be more use of this type of buoy in the future as winter aids to navigation in the Great Lakes-St. Lawrence Seaway System.

*Deployment and testing of radar transponder beacons (RACONs)*

An evaluation of radar transponder beacons (RACONs) was conducted by the Coast Guard. The RACON is designed to transmit a response to a ship's radar signal, enabling long-range detection of a shore target and better range determining capability.

The range enhancement is a significant factor for safe navigation during an extended season because ridges caused by windrowed ice can create a false display of the shoreline, thereby introducing position uncertainties. RACON displays on ship radar screens indicate the bearing and range to the unit and the signal can be coded for positive identification. Detection ranges averaged 8 to 16 miles, depending on the type of ship's radar.

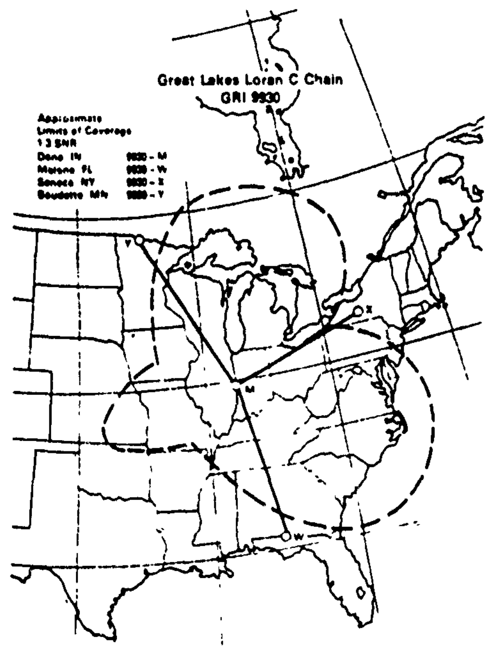
RACON installations in prior years yielded a radar response of 90-150 seconds, which was considered an excessive delay. Modifications to four of the six units were provided to decrease the response time to approximately 30 seconds. The RACONs were deployed at several locations in the St. Marys River.

The RACON response interval is a function of both the rotation speed of the radar antenna and the bandwidth of the radar receiver. Generally, slow rotation speeds (20 RPM or less) and wide bandwidths (12 MHz or higher) improve the detection interval most successfully. More frequent response times cause slight decreases in detection ranges for certain ship radars. Despite this decrease, most users favor the shorter interval between responses.

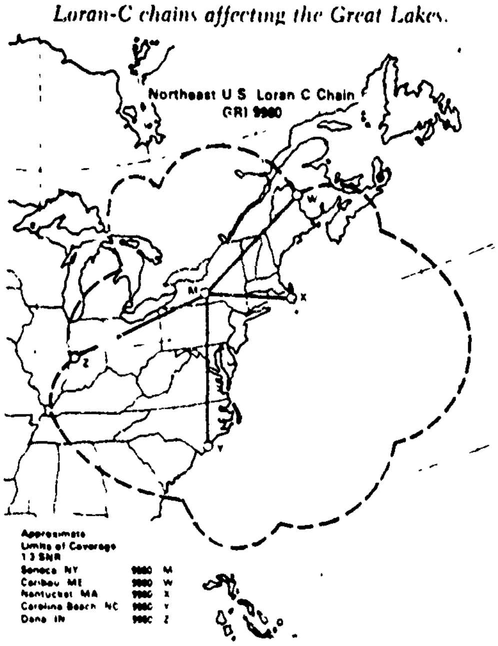
*Mini Loran-C radionavigation system tests*

Loran (Long Range Navigation) is a highly accurate position determining system which utilizes the difference in the time of arrival of radio frequency pulses broadcast by three or more broadcasting stations. Simpler to operate than a television set, Loran-C receivers are offering vessel officers position fixing systems capable of determining a vessel's "fix" with accuracy within one-quarter of a mile.

A Mini Loran-C, a scaled down Loran-C system involving a low power transmitter, has been installed to provide precision radionavigation coverage of the




*Loran-C chains affecting the Great Lakes.*




St. Marys River. The system consists of unmanned transmitters located from 30 to 100 miles apart which are precisely controlled by a monitor located in the coverage area. The Loran-C coverage area includes the St. Marys River from Whitefish Bay in Lake Superior to DeTour Passage in Lake Huron.

To provide the desired coverage in all areas of the St. Marys River, and to provide the accuracy required for a precision guidance system, four stations (two in Canada and two in the U.S.), are used, each transmitting 100 watts.

Each transmitting station is continuously monitored at the Sault Ste. Marie monitoring station, and is remotely controlled to maintain the required accuracy.

The position accuracy desired in such a system in a region where it is precisely controlled is on the order of ± 25 feet

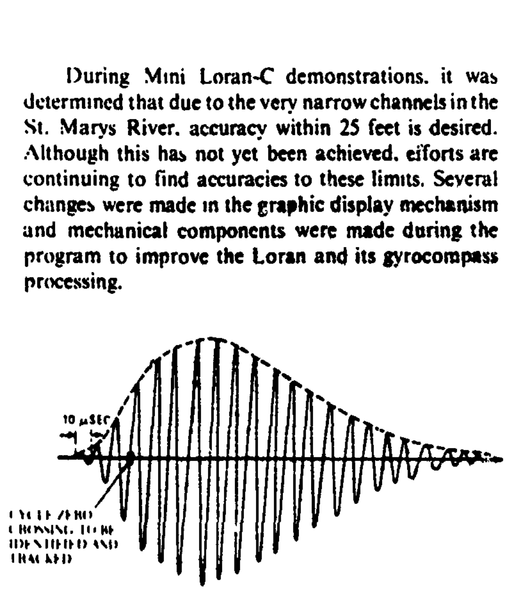
The Mini Loran-C chain is operated and controlled by the U.S Coast Guard and is officially under evaluation and test status The demonstration performed at the St. Marys River was to show that a main traffic control system using Loran-C is an effective way to control the passage of vessels through a congested area.

To accomplish that objective, the system must possess a high level of precision necessary to safely navigate in the region and a method of monitoring the progress of vessels in the area from a central location.

In the demonstration system, the precision is shown by processing signals produced by the Mini Loran-C chain and displaying position data on board a vessel, and a remote monitoring function is shown by sending the same position data over a VHF radio link and displaying it on shore. The plot of display on shore, drawing the same track for the vessel as the shipboard plot of display that takes the position data directly from the Loran receiver, provides a real time remote record of the vessel's progress.

The shipboard Loran-C Precision Guidance System was first installed in the fall of 1976 aboard the USCG Cutter *Naugatuck*, a 110-foot tug operating out of Sault Ste. Marie, Michigan. Tests were performed to calibrate the system and check positional accuracy. Additional tests were performed aboard other U.S. Coast Guard vessels and a 767-foot Great Lakes carrier.

During Mini Loran-C demonstrations, it was determined that due to the very narrow channels in the St. Marys River, accuracy within 25 feet is desired. Although this has not yet been achieved, efforts are continuing to find accuracies to these limits. Several changes were made in the graphic display mechanism and mechanical components were made during the program to improve the Loran and its gyrocompass processing.




*Loran-C pulse.*

After the changes the test system was installed on the USCG *Mackinaw* for its winter icebreaking mission. It has shown some ability for providing useful guidance information for navigation in restricted waterways. In addition, the severe vibrations caused by the icebreaking operation of the *Mackinaw* was a good test of the system's mechanical ruggedness.

Additional operational testing is required to fully evaluate the system's navigational capability, ability to follow the same course, and accuracy from end to end of the St. Marys River.

*Precise laser and radar aid to navigation system (PLANS and PRANS) tests*

The Maritime Administration contracted for the study of a precise all-weather navigation system to evaluate several alternative navigation configurations for use in restricted navigation waters.

The objectives of the test program were to acquire engineering data, verify system operation, analyze operational constraints on shipping, and to assemble information pertinent to the specific needs of a Great Lakes all-weather navigation system design. The contract called for the design and construction of a hybrid shipboard radar laser precise navigation system which would consist primarily of laser and radar transmitter receivers. A single processing computer, a counter and a display unit were installed on a test vessel. Twenty-nine retro-reflectors and four laser retro-reflectors were installed in 21 locations on the St. Marys River in a 34-mile area adjacent to Sault Ste. Marie to establish the test range, and provide coverage for 12 channels.

The position of the retro-reflectors were accurately surveyed and incorporated into the computer program for the navigation system.

Optical and radio-frequency ranging techniques were utilized, employing both a pulsed laser and a pulsed radar as inputs. A computer, an ultra high speed interval timer and various signal conditioning and control circuits were integrated to provide real time information pertaining to the vessel's position and attitude in the narrow channels. The output displays the distance to the next turn, the distance, right or left of the channel centerline, the angular difference between the vessel's heading and the centerline of the channel and the true speed over the bottom.

Because the accuracy of the laser sub-system had been verified during laboratory testing, efforts were initially concentrated on providing an accurate radar system. During testing of the system problems arose when conditions of poor visibility obscured the laser beams. This required that the radar mode be accurate in order to satisfy the all-weather design of the system. Due to this deficiency, the decision was made to drop the laser mode of the system.

The evaluation of the experimental precise navigation system demonstrated the ability of a computer-controlled system to automatically produce accurate real-time navigational data for a continuous series of courses through restricted waters. Observations indicated that a practical, all-weather, precise navigation system can be produced utilizing a dedicated radar integrated with a mini-computer.

An internal agency decision was made within MARAD not to pursue further developmental work on PRANS until results of the St. Marys River Mini Loran-C chain installation could be judged, because MARAD did not want to duplicate efforts. The Winter Navigation Board did not consider the PRANS system and the Loran-C system competitive. The PRANS activity was transferred to the St. Lawrence Seaway Development Corporation as part of its study entitled, "Definition of All-Weather Navigation Requirements for the St. Lawrence Seaway."

*Development of precise all-weather aid to navigation system (PAWNS)*

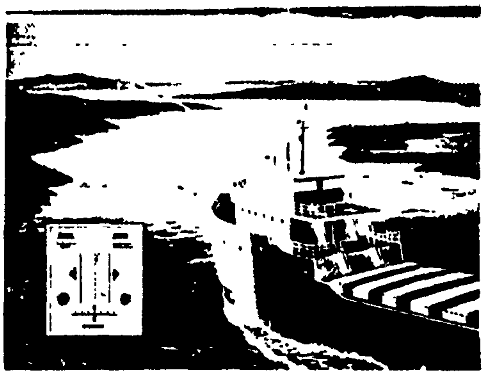
The formation of ice in the St. Lawrence Seaway in late fall necessitates the removal of lighted buoys,

thereby prohibiting navigation during night time and periods of low visibility. To meet the requirement for extension of the navigation season, and to increase the Seaway capacity, the St. Lawrence Seaway Development Corporation has been investigating the feasibility of providing a precise, all-weather, electronic navigation system which will permit operation during periods of darkness and low visibility.

The program is a two-phase study which includes (1) a system engineering study to determine electronic navigation accuracy requirements necessary to maximize Seaway capacity and maintain safety standards and (2) demonstration and evaluation of several electronic navigation systems in the Seaway to determine the applicability of a precise all-weather navigation system to the Seaway.

Two separate system engineering studies were performed and completed during FY 77-78. The first study described the characteristics of the Seaway, identified the high accident areas and established requirements for vessel guidance and navigation within the Seaway. The second study developed the capacity versus electronic navigation aid accuracy relationships for Seaway operations, as well as recommendations for a system specification, which included a data processing and display system.

During FY 79, a navigation demonstration was conducted on the Seaway, using modern electronic navigation equipment. The demonstration facility included a precision reference system, two positioning systems (LORAN-C and RAYDIST-T), and a data display system.



*Precise laser aid to navigation system (PLANS).*

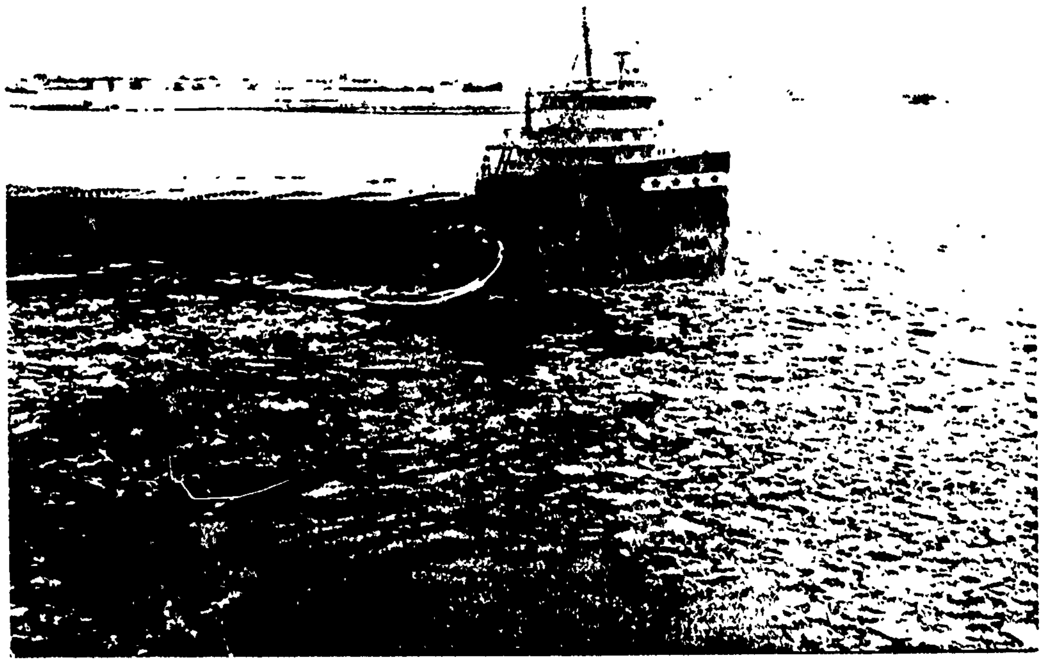
The demonstration data allowed refinement of system performance specifications initially defined in the requirements study. The section of the Seaway between Iroquois and Snell Locks, near Massena, New York, was selected as the demonstration area. System performance was measured with conventional surveying techniques as well as with an electronic precision reference system (Del Norte Trisponder). A data acquisition computer processed signals received from the positioning systems and from the precision reference positioning system for subsequent analysis. The shipboard display graphically provided piloting information obtained from the positioning systems and the ship's gyro. The display, a refinement of the equipment used by the U.S. Coast Guard in the mini LORAN-C tests at the Soo, showed the ship's location, heading and velocity on a computer generated map of the Seaway channel which included shorelines and prominent landmarks. The acquisition system is collecting data which will allow a comparison of the dynamic positions determined by the demonstration systems and the precision positioning system. These data will provide the basis for the statistical evaluation of the demonstration systems.

*Follow-the-wire guidance system*

The Coast Guard investigated a system for ship guidance in channels, harbors and other waterways using a magnetic field generated by undersea cables. The purpose of the investigation was to discover a short-range, high-accuracy system which would be effective under low visibility conditions and would not be affected by high winds and ice. Such a system could substitute under certain limited conditions, for buoys, which are easily damaged at dry dock stations by severe winds and ice.

The wire guidance system consists of an electrical conductor deployed at the bottom of a waterway, along a prescribed course or channel. The water is energized with a low frequency alternating electric current. The magnetic field created around the wire is detectable by using a wire coil. Two such coils are mounted perpendicular to each other and are applied to the vertical and horizontal deflection plates of an oscilloscope, generating an elliptical figure.

The figure on the oscilloscope rotates in accordance with the lateral position of the craft coil with respect to the wire. This phenomenon allows a vessel with a properly installed system to accurately follow the course of the wire installed on the bottom.



*Great Lakes tug assists ore carrier in ice.*

The essential feature of the sensing system was the fact that the vertical component of the magnetic field vanished at points directly above the cable, which was an indication of desired position. The results of the follow-the-wire investigation were sufficiently promising to warrant further investigation leading to a prototype installation.

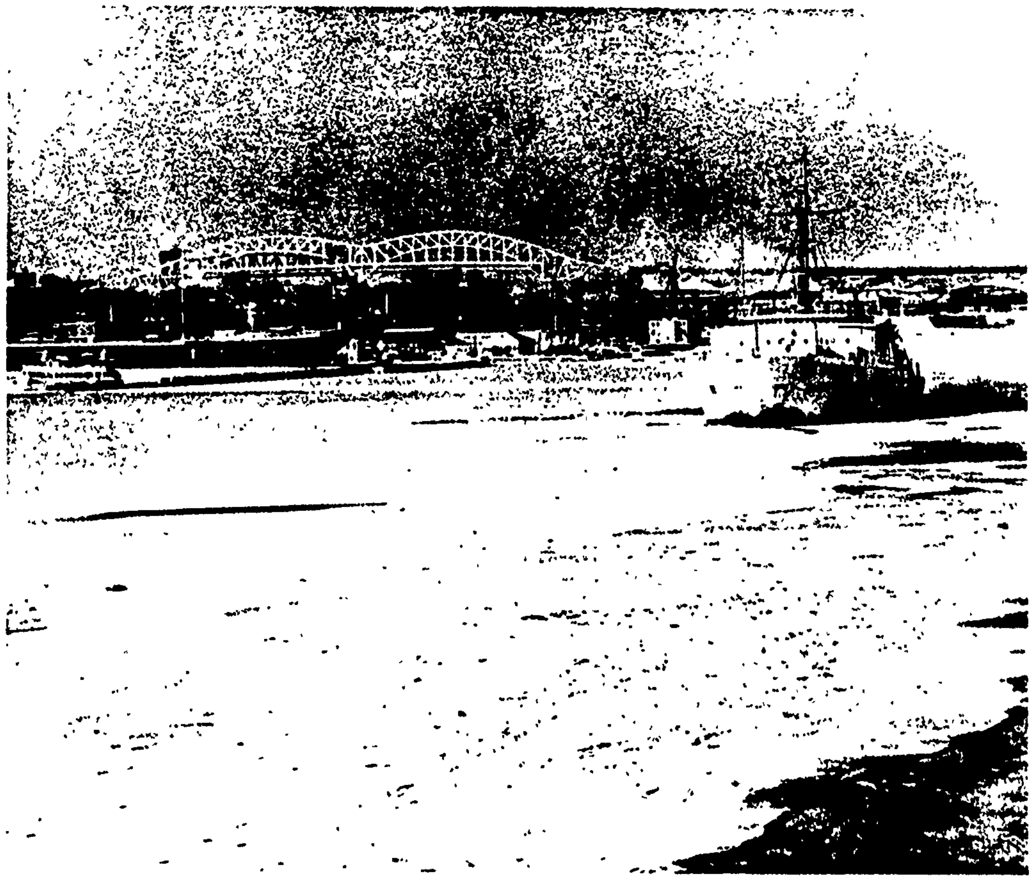
The Coast Guard performed field trials of a follow-the-wire system. This system consisted of an energized cable which was laid for four miles by the Coast Guard cutter *Woodbine* at the bottom of the Muskegon Channel, which connects Lake Michigan and Lake Muskegon.

Sensors and display equipment were mounted on the Coast Guard cutter. Results of the field trials again were such as to encourage further investigation of the system.

Under joint sponsorship of the Corps of Engineers and the Coast Guard, a two-step project to design and install a combination air bubbler and wire guidance system was initiated in Whitefish Bay. This particular installation, however, sought to determine the effectiveness of a water bubbler system under shifting ice conditions of larger, open bodies of water. Although a system was designed, it was never tested as it was determined that this system was not as effective as Loran-C and others.

*Laser range light*

The laser range differs from a conventional range light system in that the observer does not have a direct view of the light. A very narrow light beam is aimed above the vessel and is visible due to a scattering of the light beam from minute dust or precipitation particles. The beam appears sometimes like a trolly wire in the sky, providing an accurate lateral alignment of the vessel within the channel. The laser beam could be seen clearly under clear to hazy atmospheric conditions, however, the beam was not used under heavily overcast conditions.



*The* Mackinaw *at work.*

The Coast Guard designed and constructed an experimental single station laser range light consisting of a one million candle power laser and an 8 inch diameter focusing lens It was installed on Neebish Island to cover Lake Nicolet Channel in the St Marys River.

The laser range was activated remotely from the Coast Guard base at Sault Ste Marie. In order to conserve its life, the laser range was used only upon request from a vessel transitting the lower Nicolet west range.

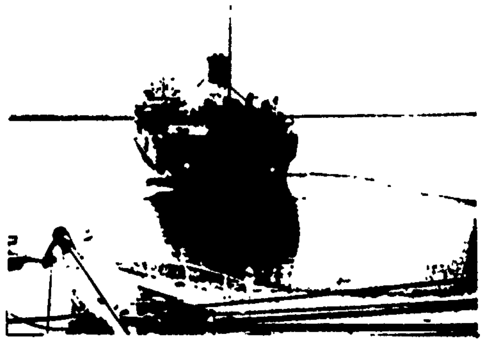
The laser range light was found not to be usable during daylight hours, however, it was extremely visible at night Ship operators reported the system may be too sensitive for mid-channel use While it was possible to position a vessel under the beam, a person on either bridge wing of a large ship could get the impression that the ship is far off the beam Further research is required to determine the usefulness of the beam under varying atmospheric conditions and what the optimum requirements of the physical components of the system for all-weather use would be.

## Ice and weather information

### *U S Coast Guard*

*Operation of Ice Navigation Center:* Ice information activities of the U.S. Coast Guard during the Demonstration Program included operation of the Ice Navigation Center, aerial reconnaissance of ice problem areas, and remote sensing of ice conditions on the Great Lakes Ongoing Coast Guard reconnaissance activities and Ice Navigation Center operations, initiated prior to the Demonstration

*A winter's night in the Straits of Mackinac.*

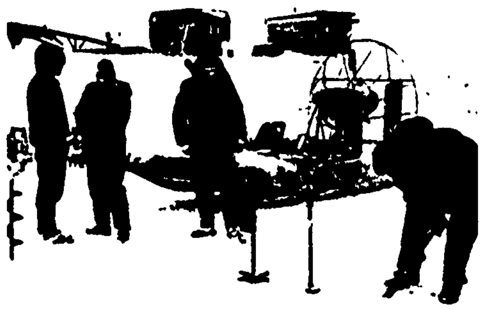


*Steamer moves through thinning ice.*

Program, were improved under the program. Remote sensing of Great Lakes ice conditions was undertaken as a joint effort by the Coast Guard, National Weather Service, National Aeronautics and Space Administration, and Corps of Engineers.

Established one year prior to the start of the Demonstration Program, the Ice Navigation Center in Cleveland, Ohio, operated seven days a week each year during the ice season. Personnel at the Center kept abreast of commercial shipping itineraries and the plans of all Coast Guard icebreakers. They also scheduled Coast Guard ice reconnaissance, collected and disseminated ice information to interested users, and validated and transmitted remote sensing imagery of Coast Guard shore stations for broadcast to merchant vessels.

The Ice Navigation Center produced an ice summary which was issued approximately three times a week. In addition, the latest ice forecast and outlook issued by the National Weather Service (NWS) were relayed by the Ice Navigation Center for broadcast from Coast Guard shore stations. The ice summary was passed to all teletype-equipped units in the Nin Coast Guard District and mailed to vessel agents high resolution telecopier network enabled the transmission of remote-sensing imagery and ice charts to the NWS Forecast Office, Ann Arbor, Michigan, and Ice Forecasting Central in Ottawa, Ontario, Canada. An information package, containing remote imagery, ice charts, a daily ice summary and wind and temperature charts, was made available to vessels transitting the Soo Locks



*Ice sampling by Seaway personnel.*

*Frazil ice in Whitefish Bay.*

*Coast Guard helicopter lands on deck of icebreaker.*

*Aerial reconnaissance and remote sensing of ice conditions* A system for monitoring ice conditions on the Great Lakes and providing near-real time information about ice location, type and thickness directly to the ships' bridges for winter navigation was developed at the National Aeronautics and Space Administration (NASA) Lewis Research Center at the request of the Winter Navigation Board.

At the heart of the system is a side-looking airborne radar (SLAR) system for detecting ice cover and type regardless of cloud cover. The Coast Guard aircraft flew over the Great Lakes three or four times a week and took radar readings of the size and location of ice cover on the Lakes

As the aircraft flies over the approximate centerline of the body of water, ice data are taken as continuing data. The data are transmitted in real time through a weather satellite operated by the National Oceanic and Atmospheric Administration (NOAA) to a ground station and relayed via telephone landline to the U.S. Coast Guard Ice Navigation Center at Cleveland, Ohio. The SLAR image is also retransmitted to the NWS Forecast Office in Ann Arbor for use in ice data analysis and forecasting.

Data are then transmitted via a VHF-FM radio link to facsimile recorders on board the ships and in shipping company offices. This process allows the ships and shipping companies to obtain a map of type, location and extent of ice in the entire lake within two to three hours after the aircraft over-flight. With this map, shipping companies can dispatch ships with safe assurance, and ship masters can plot safe and efficient courses.

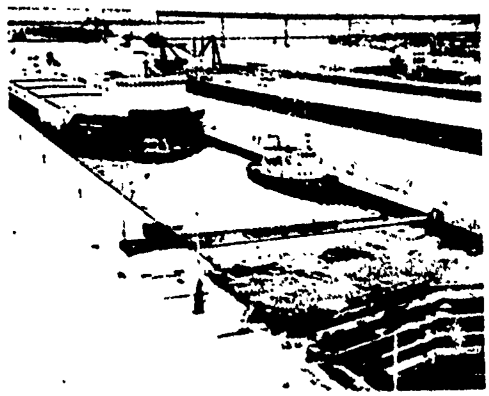
NOAA weather satellite assistance was also utilized in the Demonstration Program, on a testing basis, to provide ice information. The satellite was part of "Project Ice Warn" by the NASA Research Center at Cleveland. The project coordinated radar readings taken by Coast Guard reconnaissance aircraft with routine satellite weather picture transmissions.

*Great Lakes Environmental Research Laboratory*

*Ice thickness measurements:* The Great Lakes Environmental Research Laboratory (GLERL), has been collecting data and performing investigations on Great Lakes ice cover since 1963. The purpose of these investigations is to develop, test, and improve methods of forecasting and controlling the effects of ice and snow on navigation, shorelines, shoreline structures, power generation, and the Lakes themselves.

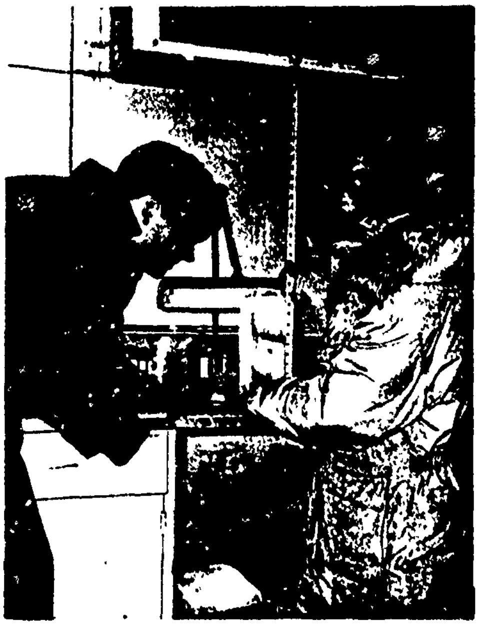
GLERL has utilized surface and aerial reconnaissance to determine ice thickness and movement, and effects on navigation. A component of the National Oceanic and Atmospheric Administration (NOAA), GLERL maintains ice measurement sites along the perimeter of the Great Lakes.

These sites, selected to monitor natural ice growth in early-freezing areas, have been used to record ice thickness measurements for over ten winters at some locations. Ice measurements were made regularly during the extended navigation season program at approximately 35 locations, 11 of which were established as part of the Demonstration Program.



*Ore carrier* Roger Blough *and Coast Guard cutter downbound in Lock at Soo.*

*Geologist stores ice sample cut from large field.*



*Geologists cut sections of ice which are then polished and examined with polarized light.*

The actual number of sites varied from winter to winter, depending upon the funding levels and upon the availability of observers. Data from selected sites were coded, tabulated and transmitted to the Coast Guard Ice Navigation Center at Cleveland for operational use at intervals throughout the winter.

*Air and water temperature measurements:* Air and water temperatures constitute two of the basic parameters needed for the development of ice formation and ice deterioration forecasting. Observation of these important parameters at selected river, bay, and harbor locations was initiated during the Winter Navigation Program.

Analog air water thermographs were installed at two locations on the St. Marys River (Southern West Neebish Rock Cut and DeTour Village) and two locations on the St. Clair River (Algonac and St. Clair, Michigan). These instruments were installed in 1972. Digital punch paper tape water temperature gauges were installed in Duluth Harbor on Lake Superior, in Green Bay and at Grand Traverse Bay on Lake Michigan and Saginaw Bay on Lake Huron in 1974. The thermographs on the St. Marys and St. Clair Rivers were removed in 1976. The digital gauges on the bay and harbor sites are still in operation.

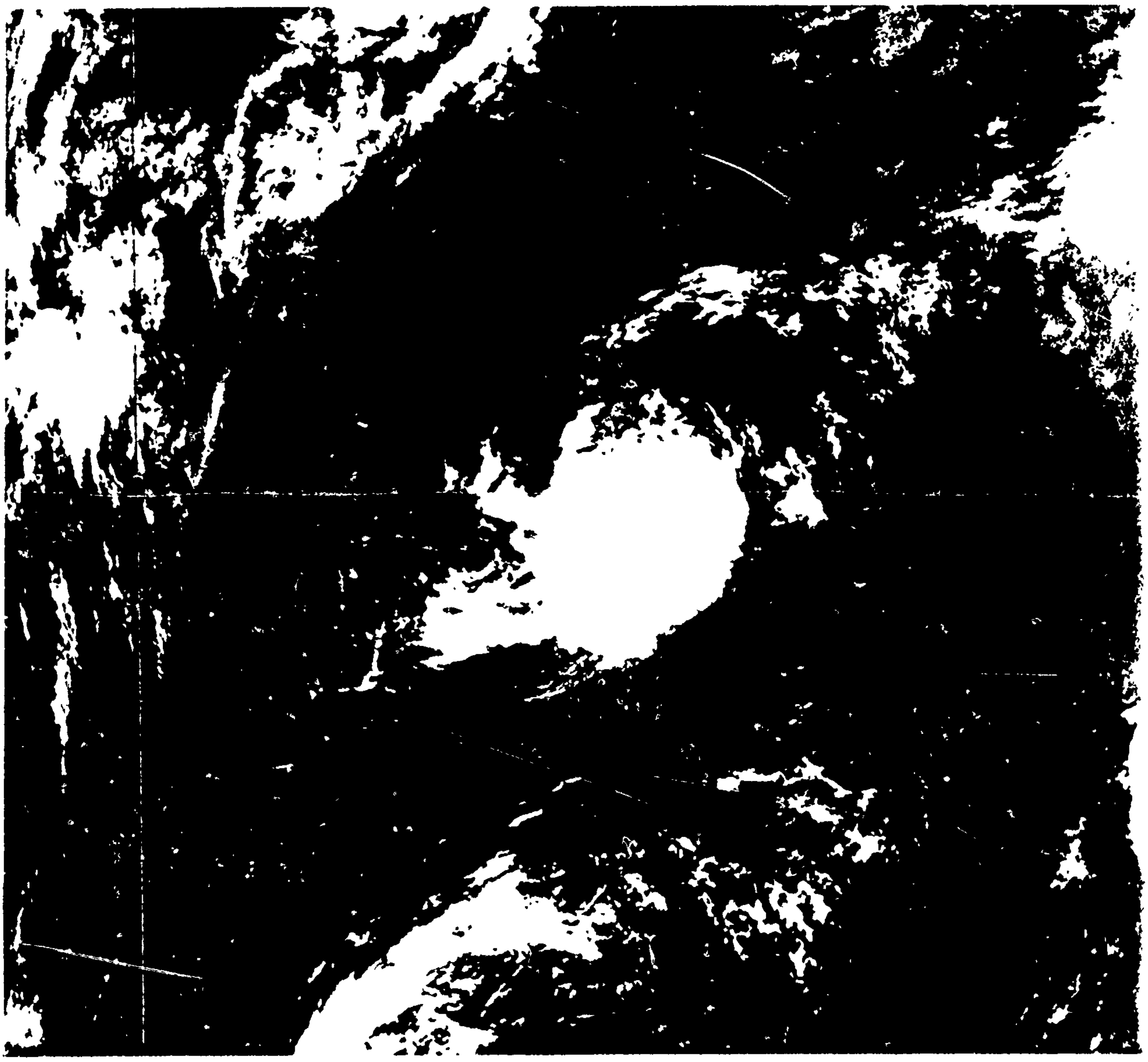
Preliminary analysis of data has been started at all temperature gauge locations, but instrument problems and time constraints have limited the editing of any further analysis of the data. Additional data reduction, editing, and analysis must be performed before evaluations can be made dealing with the application of the data for ice formation and ice deterioration forecasting.

*Bathythermograph measurements:* An important process to consider in the development of short or long range forecasting of ice information for the Great Lakes is the amount of heat stored and its annual variations. Accordingly, in winter 1972-73, a program was initiated to measure heat storage in Lake Superior during the extended navigation season. Preliminary investigations covering 20 cruises over four winters (1972-76) documented heat storage.

Measurements were conducted with an expendable bathythermograph system carried by domestic vessels, which were taking part in the extended season program. After each cruise, data were forwarded to the National Weather Service and the Ice Navigation Center for incorporation in ice forecasts. An assessment of current ice conditions was made.

A four-year program to document fall heat storage in Lake Superior began in 1976 As in the winter program, preliminary field data are made available on a near-real-time basis to the National Weather Service and are used in making operational long-range ice forecasts.

*Development of ice forecasting techniques:* The Great Lakes Environmental Research Laboratory (GLERL) directed research in ice forecasting specifically for the extended navigation program in two areas: the development of freeze-up and break-up forecasts on the St. Lawrence River and the development of special daily ice forecasts for the Little Rapids Cut of the St. Marys River. The ice forecasting techniques developed in the areas were implemented by the National Weather Service.



*Winter storm over Great Lakes as seen from satellite*

Long range freeze-up forecasts for the St. Lawrence River, based on the procedure developed at GLERL, were initiated by the National Weather Service in the fall of 1975. Operational forecasts of the probability of ice related shore problems in Little Rapids Cut were begun in the 1974-75 winter season. GLERL developed a model to predict the ice breakup period in the St. Lawrence River. The ice breakup forecast technique is used to allow advanced scheduling of ocean trade vessels into the system.

In addition to the ice forecast study, made specifically for the winter navigation program, GLERL has developed a technique to make long-range predictions of maximum ice extent on each of the Great Lakes. GLERL has also developed a technique to make forecasts of ice thickness in a specific river, bay, or harbor location on the Great Lakes. The results of these and other ice forecasting studies are available in National Oceanic and Atmospheric Administration (NOAA) technical memoranda and journal articles.

*Ice build-up on ship.*

*Data collection for St. Lawrence-Eastern Ontario Commission Shore Structure Study.*

*National Weather Service*

*Ice forecasting:* The Weather Service Forecast Office (WSFO) in Ann Arbor, issues ice analyses, forecasts, outlooks, and warnings for all the Lakes and connecting channels above the Welland Canal. WSFO Buffalo is responsible for ice forecasting on Lake Ontario and the upper St. Lawrence River. Buffalo issues a Freeze-up Outlook in early November for the St. Lawrence River below St. Regis Island. Only limited ice forecasting service has been provided for Lake Ontario.

WSFO Chicago also prepares a weather synopsis for the Great Lakes and two hourly storm summary bulletins when conditions warrant.

Teletypewriter messages are transmitted on the Great Lakes Marine Weather Circuit for broadcast by Coast Guard and commercial facilities. Ice charts are sent to the Coast Guard Ice Navigation Center in Cleveland via telecopier and are also disseminated to users by commercial radio-fascimile.

The following products issued by WSFO Ann Arbor, cover the winter operating needs for pre-winter and post-winter planning, for short range decision-making, and for long range navigational planning:

Teletypewriter Products -

a. *Freeze-up Outlook.* Issued the 1st and 15th of November and thereafter until general ice cover stabilizes. Departure from normal freeze-up, water temperatures, summary of NWS 30-day weather outlook.

b. *Great Lakes Ice Forecast.* Current weather synopsis and ice conditions plus 24 to 30 hour forecast of winds, temperatures, ice coverages; issued daily at 1600 EST.

c. *Great Lakes Ice Outlook.* Similar to forecast except covers 3 to 5 day periods; issued daily at 1030 EST.

d. *Ice Watch Bulletin.* Issued when necessary to alert users to initial ice formation or expected worsening of conditions over the next several days for key areas.

e. *Ice Warning Bulletin.* Issued when necessary to warn of rapid (24-hour) change in conditions having a significant effect on navigation or when severe conditions are present but not known.

f. *Break-up Outlook.* Issued in early March. Natural vs. icebreaker assisted opening of navigation, temperature outlook, winds, ice deterioration, weather synopsis.

Facsimile Products -

a. *30-day Ice Outlook.* Issued twice monthly starting early November. Portrays schematic percentage of expected ice cover.

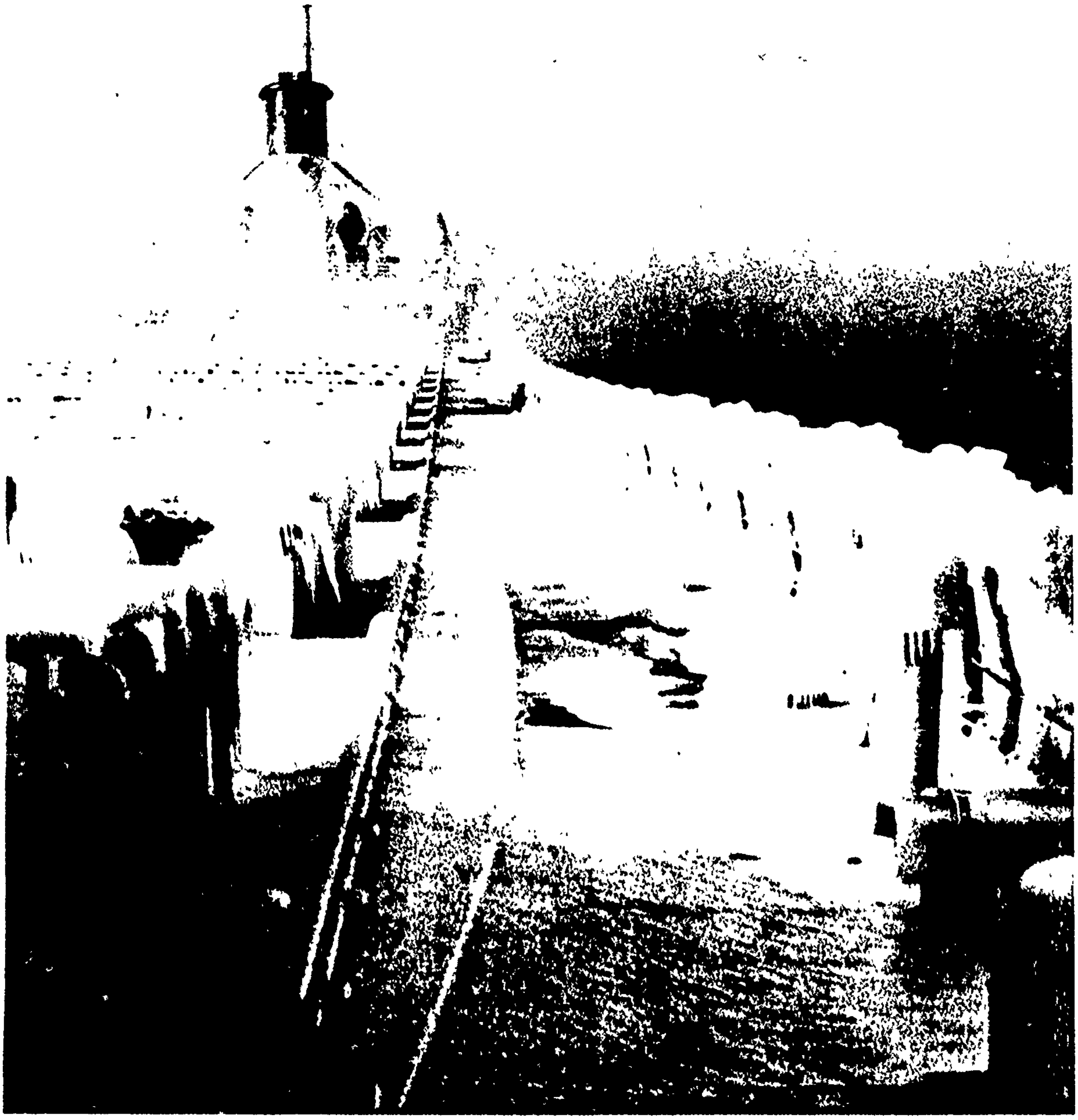
b. *90-day Ice Outlook.* Issued December 1. Same information as above.

c. *Ice Analysis.* Issued three times a week in early afternoon. Extent and distribution of ice cover, type, thickness, movement.

d. *Wind and Temperature Forecast.* 24 and 36 hour charts of isotherms, wind speed and direction, highs, lows and fronts, valid 0700 EST and 1900 EST the following day. Issued daily at noon.

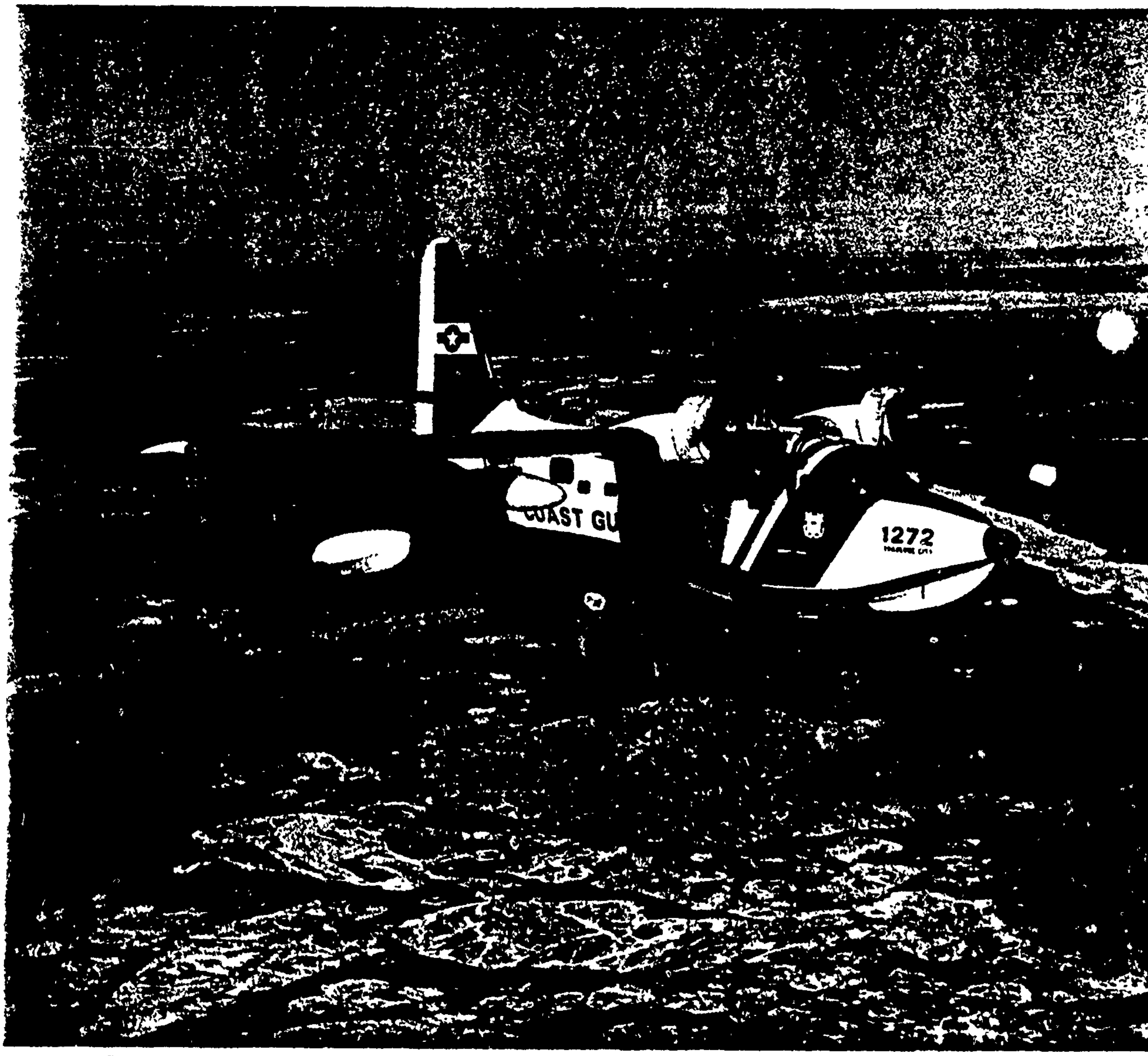
A NWS forecaster was stationed, during the program, at the Coast Guard Ice Navigation Center in Cleveland as liaison with the Ninth District HQ. This individual advises the Coast Guard on weather and ice conditions relative to ice breaker activities; analyzes ice data acquired from ground, satellite and Side Looking Airborne Radar observations; coordinates daily with ice forecasters at WSFO Ann Arbor; and disseminates information to shipping interests.

A major component of the National Weather Service dissemination system for marine services in the Great Lakes is the Great Lakes Marine Weather



Teletypewriter Circuit, created during the Demonstration Program on a test basis, by extending and consolidating several smaller pre-existing systems. This circuit connects all WSFO's, many Weather Service Offices, the Ice Navigation Center, the appropriate offices of Environmental Canada, the Great Lakes Marine Radio-telephone stations and private subscribers. Messages are exchanged year-round between the circuit and the Coast Guard Communications system at the Ice Navigation Center.

Weather observations transmitted on this circuit include (1) ship observations gathered by commercial marine radio telephone stations, (2) observations gathered on the Ninth Coast Guard District communications system, and (3) observations from automatic stations interrogated by NWS offices around the Lakes.



*Coast Guard Albatross photographed above Straits of Mackinaw during ice reconnaissance flight*

*Corps of Engineers*

*Ice surveillance* Ice surveillance activities on the St Marys River, the St Clair-Detroit Rivers System, and the eastern end of Lake Erie, were conducted during the Demonstration Program by the Corps of Engineers

*Winter Navigation Reporting Center:* The Detroit District, Corps of Engineers operated the Winter Navigation Reporting Center for the last three years of the program Daily reports were compiled containing the following information weather conditions in the Great Lakes area, detailed Soo area weather; lockages at the Soo Locks, vessels transiting the St Marys River System; identification of vessels requiring Coast

Guard assistance; ferry operations at Drummond, Sugar and Lime Islands in the St. Marys River and Harsens Island in the St. Clair River; Coast Guard operations on the Great Lakes, i.e., icebreaking assistance; and potential flooding problems due to winter navigation operations.

This information provided an overview of ice conditions on the Great Lakes as well as helping to spot and prevent or alleviate problems with ferry transportation, flooding due to ice jams and vessel movement.

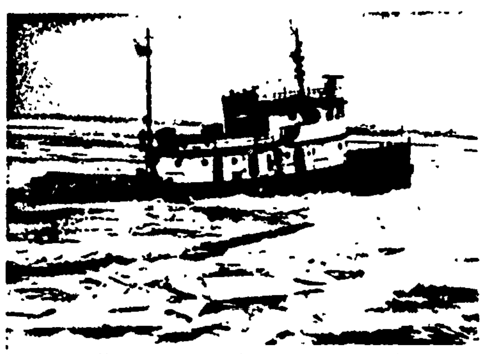
*Ice thickness measurements:* Activities on the St. Marys River included ice thickness measurements throughout the winter at six locations between the Soo Locks and Lake Nicolet. These sites, used for ice measurements since 1968, provide a good measurement for the comparison of ice seasons. Observations were forwarded to the Ice Navigation Center to provide updated information on ice conditions for both the Coast Guard and for commercial vessels.

Ice thickness measurements were taken in conjunction with ice movement measurements at sites between Soo Harbor and DeTour Passage. Marks were placed at measured distances in the ice and monitored for the type and rate of lateral displacement.

Bi-weekly ice thickness and ice characteristic measurements were taken at selected sites in the South Channel of the lower St. Clair River to study ice growth patterns. Ice movement studies were also conducted using dye and wood targets on the ice jam area to determine effects of ship passage.

*Replica of ore carrier moves downbound through main Galop ice boom in St. Lawrence River ice model.*

*The Seaway Corporation's ice breaking tug*, Robinson Bay



*Corps of Engineers vessel transits ice field*

*Vessel moves up track.*

*Time-lapse photography:* Ice formation and movement in the Soo Harbor were monitored by a time-lapse movie camera installed in the 300 foot high Observation Tower that overlooks the Soo Harbor, as well as in a Coast Guard tower upstream of the Sugar Island ferry crossing. This camera provided excellent coverage of ferry crossings at Little Rapids Cut, and documents ice conditions occurring the years before and during the St. Marys River navigation ice boom demonstration.

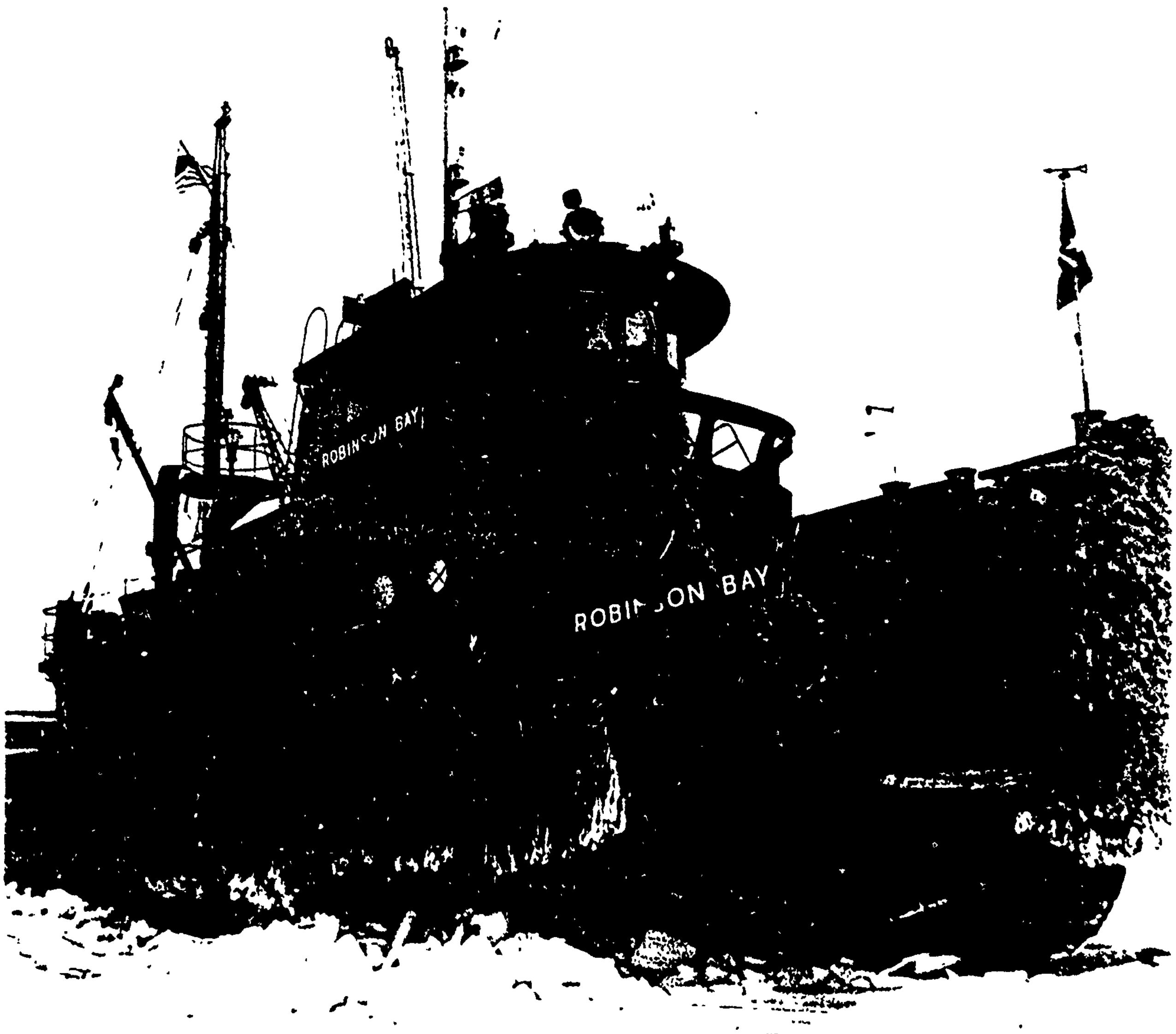
This film record was valuable in determining the amount of ice that bleeds through the navigation gap in the St. Marys River ice boom. Also observed was the effective use of icebreakers to break an ice jam in the Cut that was a threat to ferry operations. Cameras remained in operation throughout the ice season.

A similar camera installation was located at DeTour, Michigan to record ice conditions across DeTour Passage at the Drummond Island ferry crossing, and the possible effect of winter navigation on the area with regard to the ferry crossing site.

Data acquisition and surveillance on the St. Clair-Detroit Rivers System were also conducted during the Demonstration Program. Time-lapse photography was utilized to document ice conditions, particularly the results of vessel passage through the ice bridge in Lake Huron at the head of the St. Clair River.

*Aerial photography:* Aerial photography was utilized to provide documentation of ice conditions on the St. Marys River and to monitor ice conditions in critical areas of the navigation channel. Regularly scheduled flights were flown in support of Corps of Engineer's ice surveillance activities on the St. Marys River. The project has proved to be one of the best means for documenting ice conditions, ice fractures, and ice problem areas over the entire river system.

Aerial photography was also used to survey and document ice conditions in critical areas throughout the Great Lakes-St. Lawrence Seaway System. Ice charts of ice coverage in the system between Lake Huron and Lake Erie were prepared.




*St. Lawrence Seaway Development Corporation*

*Ice surveillance and monitoring of St. Lawrence River:* The St. Lawrence River ice and weather data collection program began in the fall of 1971 and has continued throughout the program. It has comprised the application of a wide range of available techniques for documentation of winter conditions as well as the development of modified techniques to address special problems. The program was directed toward filling data gaps and complementing the data collection efforts of other agencies.

Ice coverage was documented by vertical aerial photography flown on approximately one week intervals, with more frequent coverage during the ice formation and break-up periods. This coverage was supplemented by aerial reconnaissance and oblique aerial photography, as well as by time-lapse photography in selected locations.

A limited program of ice thickness measurements was undertaken to supplement the extensive network of ice measurements taken each winter by the Canadian St Lawrence Seaway Authority. Radar and manual profiling of the ice in the Cardinal to Wad-

*The* Edisto *is shown upbound at Sugar Island Ferry lane at Little Rapids Cut during 1972 demonstration tests.*


dington area was accomplished to document the hanging dams which occur in that reach of the River.

An ice marking and monitoring study was performed to refine techniques for monitoring ice movement. These were utilized in the Copeland Cut test boom project and at Ogden Island.

Recording and telemetering thermographs were installed at three locations to provide input data for navigation season closing decisions and for support of ice forecasting activities. Two supplemental automatic weather stations were installed in cooperation with the National Oceanic and Atmospheric Administration-Great Lakes Environmental Research Laboratory (NOAA-GLERL) to provide data on the climate at the river.

A shore erosion/shore structure damage monitoring program was carried out for the final four years of the program. The U.S. shoreline was mapped, and shoreline and structures were classified in terms of the potential for ice impacts. Selected structures and erosion-prone areas were monitored photographically and with surveying equipment to provide baseline data on natural ice impacts.

## Safety/survival

*Survival equipment development and tests*

Attempts to assess the adequacy of shipboard escape and survival systems, and to identify areas where improvements are needed, were initiated by the Coast Guard at the request of the Winter Navigation Board Initial efforts were made in the direction of a systematic study to define the problems and to investigate the effectiveness of various solutions.

The primary areas of survival investigation included individual exposure protection, group exposure protection, distress, alert and detection enhancement, and an overboard alarm system.

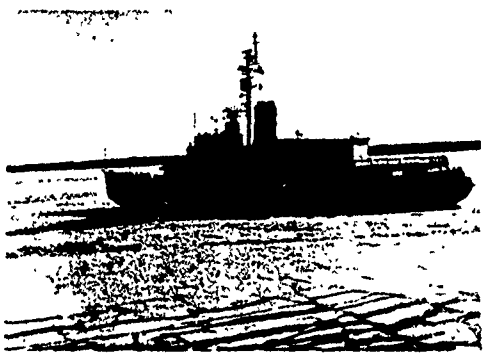
Investigations included a prototype constant exposure jacket (developed by the Naval Air Development Center), an enclosed survival module, and the determination of survival times in cold water while wearing typical seaman's winter clothing.

A private laboratory was contracted by the Coast Guard to study the requirements for survival on the Great Lakes and to evaluate the application of survival suits to crew survival.

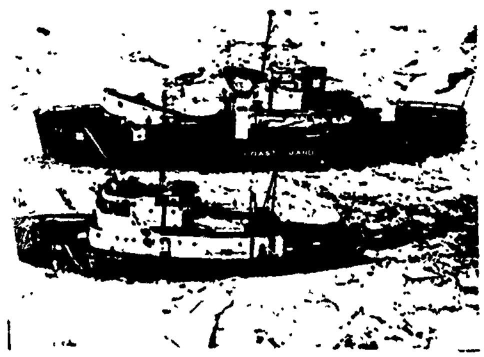
The study was designed to produce four outputs. (1) the environmental conditions which must be satisfied in the design of any survival system or equipment; (2) the functional or performance requirements which must be satisfied by such survival systems and equipment, (3) test plans for the evaluation of survival systems and equipment; and, (4) identify areas where inadequacies exist and additional development and research efforts are needed.

Through the use of simulation and computer models, specific requirements were established. The problem of immersion hypothermia (lowered body temperature) to Great Lakes casualty victims and the lack of a suitable alternate to the use of exposure suits, led to the investigation of the life saving potential of existing and specially designed personnel exposure suits.

Survival time due to exposure to cold was determined. For the normal range of temperatures of lake



*The Westwind at work during the program.*



*The Ojibwa is foreground with Mariposa.*

water (32° - 55° F), these times are quite short. In 32° - 33° F water, the expected time of survival without special protection in water is from 15 to 45 minutes. In 40° - 50° F water the range is from one to three hours. The initial shock via entry often incapacitates many victims.

In the study, hazards were identified and solutions were evaluated including the evaluation of a variety of commercially available suits. Two suits which are commercially available appeared suitable for use in that they provided complete coverage for the body and extremities, leaving only the face exposed. Some 280 exposure suits were distributed to vessel crews participating in the extended season activity.

Information describing the latest techniques for cold water survival has been published and distributed to crew members of vessels engaged in winter navigation.

*Detection tests*

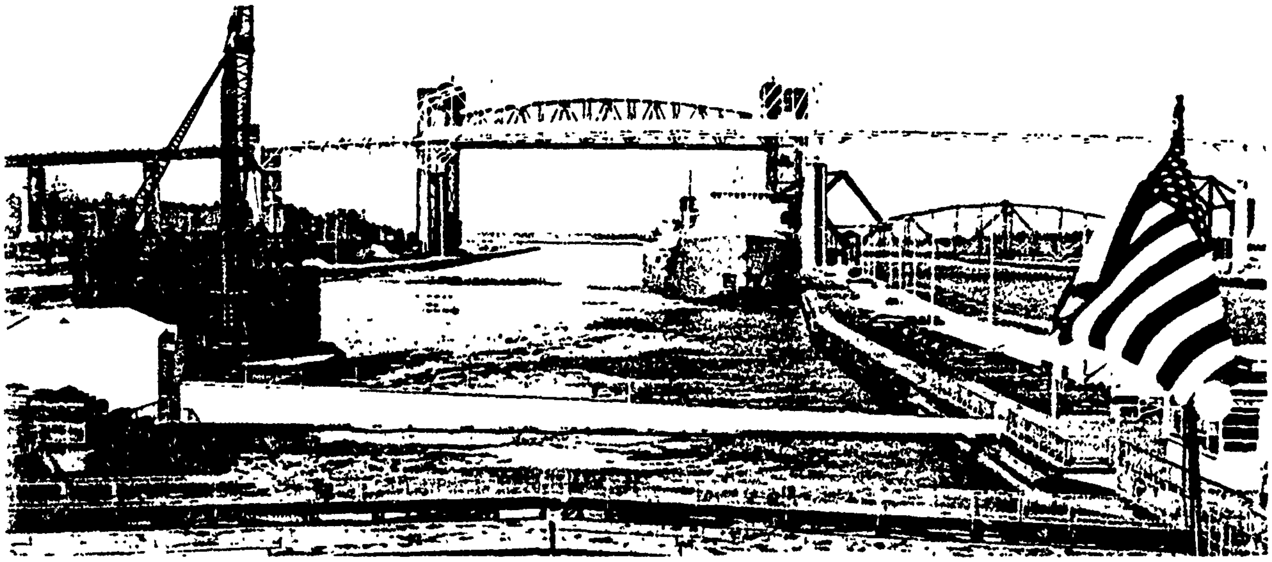
Activities in detection enhancement included an exercise in which Coast Guard personnel were set adrift on a raft in Lake Huron. This demonstration successfully utilized radar transponders and other equipment. Emergency Position Indicating Radio Beacons (EPIRB's) were also extensively tested.

A "Man Overboard Detection and Location System" was undertaken by the Coast Guard. A feasibility study indicated that there were several systems that could be initiated. The system that appeared to function best was developed into a prototype. Under the system evaluated, each person on a vessel would wear a radio transmitter with a self-contained antenna which would begin to operate automatically by means of a water activated switch whenever the wearer entered the water. A special receiver on the bridge of the vessel would sound an alarm when the signal was received. The transmitter signal then could be used as a homing device to locate the person in the water.

*Safety, survival equipment wintertime training*

Training in the use of safety survival equipment is the continuing responsibility of the vessel owner and the master.

The Maritime Administration's Great Lakes Region Office, requested to assess these training needs, communicated with major lakeship operators, seafaring unions, pilots' associations, mining companies, Great Lakes shipping associates and other Federal agencies. These groups were asked to provide comments and recommendations relevant to a viable assessment of pilot masters training needs. The questions that were posed to survey recipients were direct, simply presented and to the point. They were: Is this training essential and valuable? When should we undertake an administrative program? Who should participate in this training phase? Would you



*Soo Locks.*

support this program? How should these classes be funded? What do you consider an adequate training period?

Response to the survey indicated a consensus in favor of a continuation of "on the job" training in order for operators to provide qualified and competent masters and pilots to man vessels during the extended navigation season.

*Communication tests*

The high level VHF-FM communications system has been developed and is in current use by the Coast Guard throughout the Great Lakes.

## Levels and flows

*St Marys River*

A series of water level gauges were installed between Soo Harbor at Sault Ste. Marie, Michigan and Ontario and the lower end of West Neebish Channel and were monitored by telephone or visual inspections each day and subsequently plotted to form a hydrograph. The purpose of this activity was to aid in the early detection of ice jams as well as to study the effects of wind and/or ship passage on lower levels. Because ice jam blockage can be monitored as upstream levels rise, the opportunity develops to provide flood alerts or break up the ice jam.

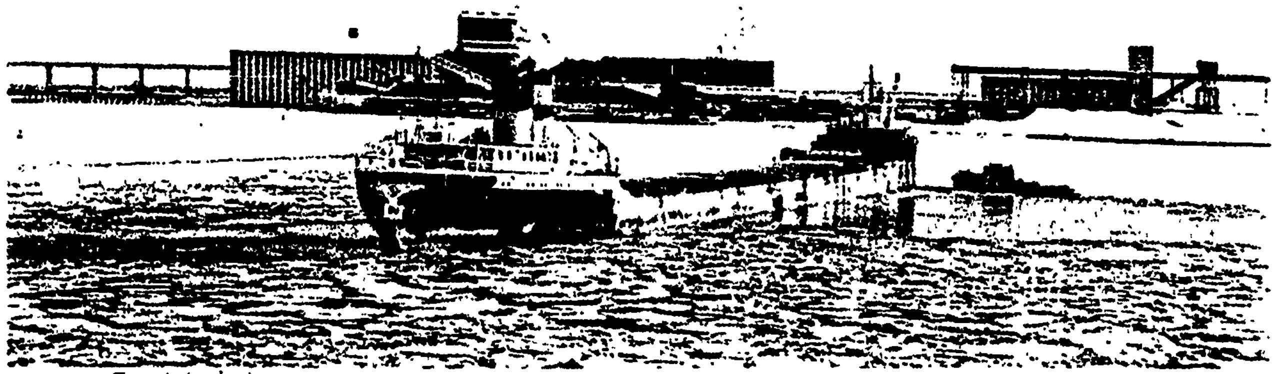
A study was undertaken on the St. Marys River to help stabilize the ice cover in Soo Harbor and to reduce the volume of ice that entered the Little Rapids Cut. A hydraulic scale model of the harbor and upper channels around Sugar Island was designed and constructed to duplicate existing flow patterns and ice conditions.

Baseline data utilized aerial photos, time-lapse photos, ice thickness measurements, water level hydrographs and meteorological data. Flow pattern studies and other hydrological data were collected as needed to aid in the model calibration. The model was utilized in testing various ice boom arrangements and other ice stabilizing concepts that would permit ship movement and still allow for stable harbor ice.

Flow discharge measurements were taken in the St. Marys River in two channels around Sugar Island to detect the effect of ice jams on flow distribution, and an operational plan to reduce flood risk was developed and issued to all participating agencies.

Two ice booms with a 250 foot navigation opening between them were installed at the outlet of the harbor to stabilize the ice flow in the harbor during the winter of 1975-76. The location and lengths of the booms had been determined previously by the model tests described above. Forces in the upstream end of the ice boom structure were monitored throughout the winter by six underwater sensors, three in each boom. Forces were recorded and supplemental data on ship passages, ice conditions, meteorological conditions, water flow and water levels were also taken

The booms proved to be highly effective in retaining broken ice in the harbor while allowing ships to transit. The booms on both sides stabilized the ice field



*Transit in the ice.*

and prevented it from drifting and jamming into the Little Rapids Cut.

Occasionally, the ice sheet between the navigation channel and the U S shoreline would break away and pivot or override the west boom, causing high stress in the boom cable. Strain gauges attached to the cable monitored the stress, which was reported on a strip chart recorder located in a heated shelter near the boom installation. On-site observers helped differentiate between natural and ship-induced effects.

Temporary rock-filled structures, which were installed upstream of the west boom to prevent the ice sheet from pivoting away from the shoreline and loading the west boom were quite effective.

The value of ice booms and rock filled structures has been demonstrated. Since these structures were installed, there have been no major disruptions to ferry service due to ice backup as previously experienced.

Field investigations and photography were effective in determining and documenting data on movement of ice. Additionally, they were used to distinguish between ice movement related to ship transits as opposed to ice movement caused by natural conditions. Field data such as ice thickness measurements, and meteorological data were provided to the Ice Navigation Center for their forecasting use.

*St. Clair-Detroit Rivers System*

As part of the Detroit District Corps of Engineers ongoing activities a data collection program was operated in this system to observe and document ice and water level conditions during each year of the Demonstration Program.

Water levels were monitored at strategic locations along both the St. Clair and Detroit Rivers. Levels were plotted at three hour intervals along with pertinent wind, ice, temperature, and ship-related data to better interpret the effects of water level change. Water levels at key gauge locations were also monitored several times each day via telephone-reporting gauges and plotted for early detection of ice jams.

When ice jams were detected (by observing the rise in upstream levels and the lowering of levels downstream of the jam), the National Weather Service and the U. S. Coast Guard were notified of potential flood conditions.

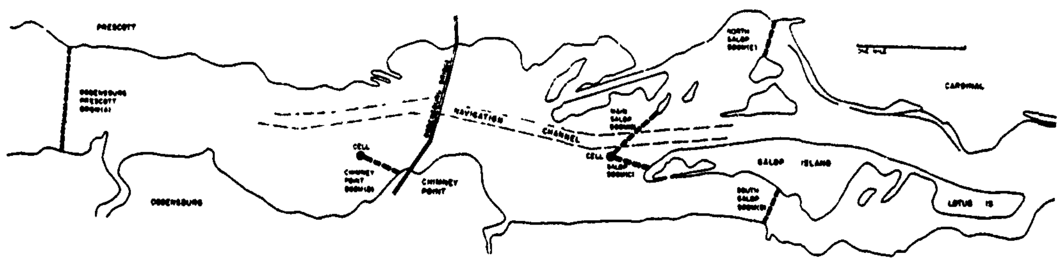
A plan of action was developed for each river that involved the close monitoring of levels and ice conditions via aerial and ground observations. More serious jams required icebreaker passage through the jam area in an attempt to break up the ice constriction.

Weekly aerial photographs were taken of the St. Clair-Detroit Rivers System to document the changing ice conditions and patterns in order to better interpret the effect of ice on levels, flows, and restrictions to winter navigation.

A time-lapse movie camera was installed each winter in the Fort Gratiot Lighthouse to document the volume of broken ice that enters the St. Clair River. In addition, it recorded the periodic formation, breakup, and effect of ship passage through the ice arch (bridge) that forms across the river entrance.

Natural wind action and vessel movement at the head of the St. Clair River has disrupted the stable ice bridge which forms above the entrance to the river. A two part model study is being performed to determine the most effective type and location of an ice control

*Location of ice booms, Ogdensburg-Prescott area of St. Lawrence River.*




structure to be placed in that location in order to stabilize the ice cover.

The model study includes a hydraulic study and a wind stress study. The models have been designed, built, and calibrated based on actual field data collected in the area. The model study is scheduled to be completed in the latter part of 1979.

A contingency plan was developed for each river involving close observation of changing levels and existing ice conditions. Close liason was maintained with the Coast Guard and National Weather Service to analyze imminent problems and decide upon the best course of action to reduce any flood threats.

*St. Lawrence River*

Substantial improvements in the existing ice control systems in the St. Lawrence River will be required before any significant extension of the navigation season is possible. Required Canadian improvements are being addressed by the St. Lawrence Seaway Authority of Canada. In the International portion of the river, the major required improvements are in the International Rapids Section, between Ogdensburg and Waddington, New York.

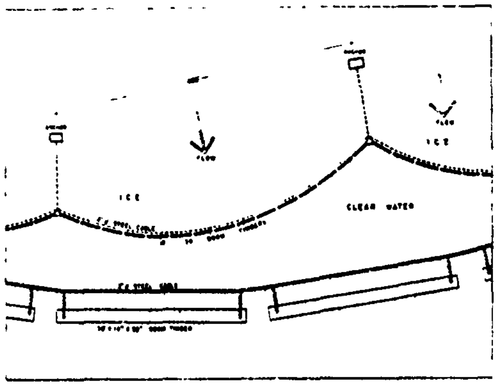
Initial efforts by the St. Lawrence Seaway Development Corporation's (SLSDC) program in the first two years of the program were directed at installing and testing a movable gate in the Ogdensburg-Prescott ice boom, which crosses the navigation channel. Concerns of the power entities precluded anything but open water testing of this modification.

At the same time, SLSDC contracted for a systems analysis of St. Lawrence River season extension. This study, entitled System Plan for All-Year Navigation (SPAN) identified constraints to extended season navigation between Montreal and Lake Ontario and proposed three levels of alternatives for removing those constraints, in 15 weekly increments, to permit navigation.

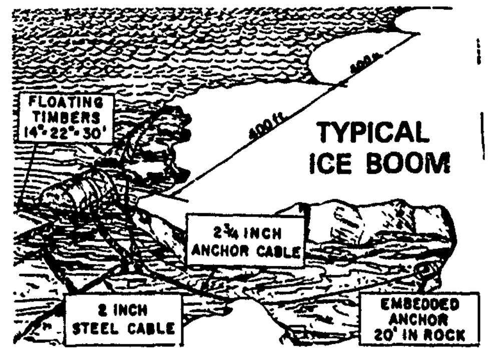
It also provided a benefit/cost analysis for each of the 45 alternatives examined. The study addressed the need, in addition to ice control improvements, for a precise all-weather navigation system, for vessel capability criteria, for icebreaking and special channel clearing devices, and for improvements at the locks. SPAN provided the basis for focusing subsequent demonstration activities.

Following these efforts, a demonstration ice boom for extended season navigation was designed for the Ogden Island area. As a result of input from other agencies, the decision was made to transfer the test to the Copeland Cut area of Lake St. Lawrence on the Wiley-Dondero Canal just above Massena, New York. This study, completed in 1975, demonstrated the technical feasibility of maintaining a stable ice cover behind a boom while navigating through it.

The focus then shifted back to a demonstration of the feasibility of commercial navigation through the booms, which the power entities install across the



*Sketch of ice booms in position.*




*Sketch shows ice boom construction.*

navigation channel at Ogdensburg-Prescott and Galop Island. This was accomplished in a phased hydraulic ice model/design effort which first calibrated the technique for modeling ice boom loads in undistorted and distorted scale models of the Copeland Cut test boom. The next study was done on the Stillwells Point to Red Mills, New York, reach of the river, in which the power entity booms are installed. The study report entitled the 1978 "St. Lawrence River Ice Boom Modification Study," presented the results of improving the existing ice booms in the International portion of the St. Lawrence River to provide for extended season navigation. The study objective was to assess the impact of ships navigating through the river in the winter on the regulation of Lake Ontario outflows and the environment along the river. The study concluded that the Ogdensburg-Prescott and Main Galop Booms can be modified to permit winter ship transits, that they will maintain the stability of the ice cover behind these booms, and that they will have negligible impact on the levels and flows of the St. Lawrence River, Lake Ontario, and power production at the Moses-Saunders power dam. This effort resulted in designs for a proposed ice boom demonstration and in designs for an ice control system which would allow all-year navigation in this reach of the river.

The actual demonstration, involving a modification of Galop and Ogdensburg-Prescott ice booms to provide an opening through which limited vessel transits could take place, did not occur. This was due to strong environmental objections by the State of New York and limited time constraints of the Demonstration Program authorization. Additional controversy arose as to the projected effects of such a test on the levels of Lake Ontario and flows associated with the St. Lawrence River. Theoretical mathematical studies were performed by the Corps of Engineers, the New York Department of Environmental Conservation and the St. Lawrence Seaway Development Corporation. These three studies yielded varying results.

An additional study was then undertaken by the Corps of Engineers to: (1) describe in detail each of the previous methods analyzed to compute impacts; and (2) establish and coordinate a set of criteria and parameters for the test and compute, using those criteria, a best estimate of the expected impacts on levels and flows.

Based on the results of the study, it was concluded that the St. Lawrence River ice boom demonstration would have no impact on the water levels of Lake Ontario, no impacts on the flows of the St. Lawrence River, and would not reduce the average water level of Lake St. Lawrence by more than approximately one-half foot. It was also concluded that these results were conservative because of the data (excessive ice release volume per ship passage) used in the analysis.

The State of New York maintained its position that any impacts occurring were unacceptable, and claimed that the state-of-the-art of mathematical models was not developed to an extent that accurate predictions could be made.

## Navigation locks

*Methods to remove ice from lock walls*

Removal of the ice collar, a buildup of ice on the lock walls caused by frequent lowering and raising of the lock water levels, has been approached in two ways: (1) mechanically cutting the ice collar or (2) chemically coating the lock walls to reduce the ice adhesion force so that removal can be facilitated.

An ice-cutting saw has been developed and is now operational. The unit consists of a 15 foot bar and chain cutter similar to that used in the coal industry. The cutter is mounted on and driven by a four wheel drive tractor. Traverse speeds of over 10 feet per minute can be steadily maintained while cutting through ice collars 2 feet in width and 6 to 8 feet deep. The ice cutting saw was used at the Poe Lock at Sault Ste. Marie, Michigan, during the winter navigation season.

*Tests to prevent ice build-up on lock walls*

The chemical coating to reduce ice adhesion forces is a copolymer compound consisting of polycarbonate and polysiloxane. The copolymer can be sprayed onto a clean surface, leaving a thin, clear, pliable film. Trial tests during the 1976-77 winter season were very promising, in that the time and effort required for ice collar removal using both mechanical means and steam was reduced.

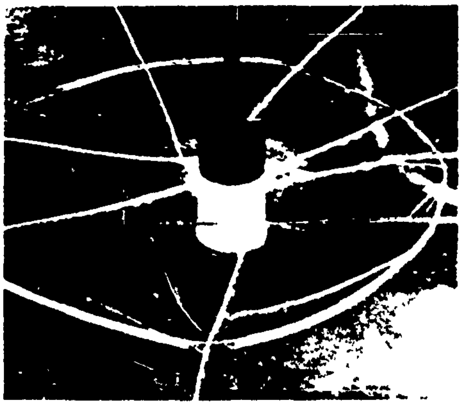
An epoxy resin undercoating was used before applying the copolymer. Presently, the entire Poe Lock, from high pool level to 10 feet below has been coated with the epoxy undercoat.

Other methods that have been tested to remove the ice collar from lock walls included a scraper blade mounted on the bow of a Corps of Engineers' tug, removal using a tractor mounted backhoe unit, a flexible lock wall panel, high pressure water jets, and the use of steam.

Of various methods tested to remove the ice collar from lock walls, the use of steamlines and hoses has proved to be most effective. This technique was particularly effective in conjunction with use of lock wall

*Backhoe scrapes ice off lock walls.*

*Strain gauge attached to ice boom anchor.*



CRREL's laboratory pile tests with fresh ice cover

Steel anchors being fabricated for ice boom gates anchor

coating chemicals While the chemical coating did not prevent ice from forming on the walls it did reduce removal time and decrease effort when used with other methods of ice removal.

*Tests to prevent ice from entering lock chamber*

Experiments to retard ice formation behind lock gate recesses involved heat cables and air-bubbler lines The air-bubbler system was utilized also to flush ice from behind lock gates and to reduce ice buildup on approach walls A bubbler line was also tested across the upstream approach to the lock. The line produced a flow pattern which pushed loose ice aside, allowing ships to pass through the lock chamber without pushing large quantities of ice ahead of them into the lock Such a system was installed at Snell Lock in 1975, at Cote St Catherine locks in 1976 and above the Poe Lock at Sault Ste Marie Michigan in 1977

Lock operating personnel, well satisfied with the operation of the high flow air stream, noted these benefits ease of gate operations with less time loss in opening and closing of gates less delay in ship lockage, and less time and effort required removing ice buildup from lock walls

Heating cables have been effectively used in lock gate machinery recesses to prevent ice buildup. Air-bubbler lines along the lock floor chamber have been effective in retarding ice formation and also for flushing ice from the lock gate recesses.

## The environment

The concurrent conduct of a Demonstration Program and a Survey Study resulted in confusion from an environmental point of view because of the radically different perception of the potential environmental effects of a short-duration demonstration activity and of a long-duration operational program. While the demonstration program, by its nature, could not resolve or settle all of the potential environmental problems, it did surface a diverse array which must be addressed in future years

*Environmental Evaluation Work Group activities*

The U.S. Environmental Protection Agency was the lead agency and Chairman of the Environmental Evaluation Work Group. Other agencies represented included the U.S. Army Corps of Engineers, U.S. Coast Guard, U.S. Fish and Wildlife Service, National Oceanic and Atmospheric Administration, Maritime Administration, and St. Lawrence Seaway Development Corporation. The work group also included state representatives from the eight Great Lakes states, an observer from the Canada Centre for Inland Waters, and the Midwest Representative of the Sierra Club.

Work group activities centered primarily upon the evaluation of environmental effects of specific demonstration projects that involved physical contact or interaction with the environment.

The environmental effects of these types of projects were first assessed by the individual work groups responsible for each project. Supervision and guidance on the data needs, methods of evaluation, and preparation of the environmental assessments were then provided to the Environmental Evaluation Work Group. Evaluations of each project were subsequently made by the agencies represented on the Environmental Evaluation Work Group.

Some of the information submitted by the participating agencies, while not specifically related to a particular demonstration project area, applied to environmental considerations for the navigation season extension over the entire Great Lakes-St. Lawrence Seaway System.

Evaluations were made according to the agency's area of expertise. In addition, both the Heritage Conservation and Recreation Service and the U.S. Fish and Wildlife Service accumulated a limited amount of baseline data covering the Great Lakes concerning their respective areas of expertise. These studies included gathering information on the location of wildlife habitats, waterfowl feeding and nesting areas, and areas of fishing activities on the Great Lakes.

A significant part of the Demonstration Program involved activities such as ice surveillance and basic data collection in which no physical interaction with the environment occurred and as such required no special environmental studies.

Activities evaluated included the bubbler-flusher system at the mainland dock of the Sugar Island ferry crossing, the Lime Island Turn air bubbler system in the St. Marys River, the Duluth-Superior Harbor air bubbler system installed near the entrance of Superior Harbor, the Howards Bay (Duluth-Superior Harbor) air bubbler system, the ice boom gate installed in the Ogdensburg-Prescott ice boom, and the Copeland Cut test ice boom. In addition, a thermal ice suppression test was conducted in Saginaw Bay in Lake Huron and an ice navigation boom in the St. Marys River was tested.

An environmental assessment for the St. Lawrence River Demonstration activities was prepared, and a monitoring program to define the environmental effects of the Demonstration activities was developed.

There were potential problems with respect to bubbler systems, effects on shore structures, shore erosion, and creation of waves under ice. Results of studies to date indicate that winter vessel movement in certain channels and narrow passages have caused an increased rate of shore structure damage, but are believed to have a minimal effect on shoreline erosion. Large vessels, passing at maximum allowable speeds, create drawdown conditions which break the ice-cover, and the resultant ice action creates damages.

In accordance with the National Environmental Policy Act of 1969, an Environmental Impact Statement on demonstration activities was filed with the Council on Environmental Quality for every fiscal year from FY 74 through FY 79. These statements, prepared by the U.S. Army Corps of Engineers, were filed prior to the start of each season and provided the basis for comparison of the anticipated and actual impacts of each activity.

In addition to these statements, the U.S. Coast Guard prepared an Environmental Impact Statement on its on-going icebreaking activities related to its statutory responsibilities.

Special studies conducted by the Environmental Evaluation Work Group included a study of the effects of winter navigation on outdoor recreation on the St. Marys River, a long-line air bubbler fish study, pressure wave measurements, and a study of turbulence effects on shallow water sediments and organisms, macrobenthos study on the St. Clair River, and preliminary evaluation of demonstration activities on the St. Lawrence River.

*Environmental Impact Statements*

Environmental Impact Statements for individual activities have been prepared during each year of the Demonstration Program. The yearly reports identify the participants in the tests, describe the demonstra-

*Ice in Lake Superior.*

tion activity, the environmental setting without the project, and the environmental impact of the activity. Included are remedial, protective, and suggested mitigating measures.

Applicable environmental data obtained during the Demonstration Program is being used for preparation of an Environmental Statement which will accompany the Winter Naviga' on Survey Report.

*Environmental data collection during air bubbler operation*

An environmental study was conducted to determine the effects of a harbor air bubbler system on the water quality of Howards Bay in Duluth-Superior Harbor during the winters of 1973-74 and 1974-75. The areas of study involved water temperature, conductivity, water samples for chemical analysis and oxygen content, and the effect of ambient temperature. No adverse effects were identified during the demonstration period.

*Monitored fish movement at proposed air-bubbler location*

The Environmental Evaluation Work Group, through the U.S. Fish and Wildlife Service, negotiated a contract with the Lake Superior State College, Sault Ste Marie, Michigan, to study fish movement in a shipping channel in the St. Marys River. In addition to gaining fish movement information, the study was to provide information on species composition and the

relative abundance of economically important fish in the St. Marys River. The study was to collect fish movement data throughout most of the 1974-75 winter season.

The study area was located in the West Neebish Channel above the Rock Cut, some 21 miles south of Sault Ste. Marie in the downbound navigational channel of the St. Marys River near Barbeau, Michigan. This area was selected principally because it is traditionally closed to navigation after 15 December.

That winter happened to be one of the mildest since the beginning of the Demonstration Program and, as a consequence, the entire study had to be completed within 12 days in March.

Two model 115 Vexilar Sonagraphs were placed in a specially constructed ice shanty to record fish movements from 5 March through 16 March 1975. A timer was constructed to run the instruments for six minute periods alternating with 12 minutes of inactivity. The recording paper was changed at least once a day, usually about 1700 hours. Three records were made with a transducer pointed straight down to determine swimming depth of the fish. For the remainder of the study the transducers were angled downwards, one to the north, the other to the east.

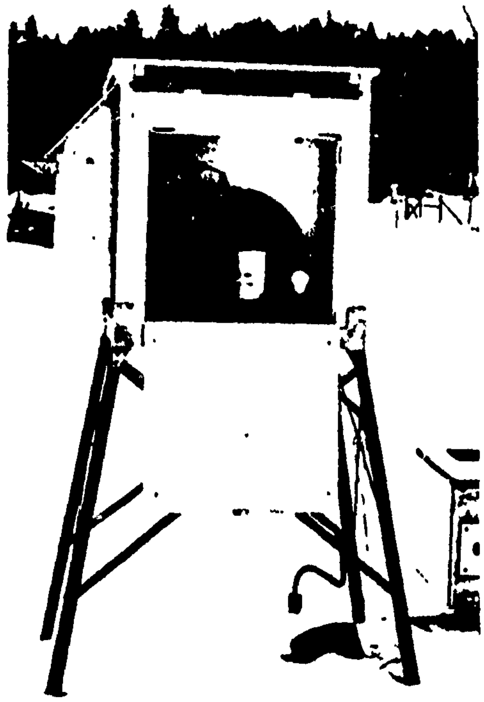
Attempts were made to identify fish with the use of gill nets in November 1974 and March 1975 but these proved ineffectual.

The monitoring of fish movement at a site in the St. Marys River was limited in scope because the effective range of sonar devices employed was small and because climatic conditions did not permit time to monitor the movement patterns of fish at other locations. The study did result in the collection of viable data, however, regarding fish activity near a navigation channel during the winter season.

*Environmental data collection at Saginaw Bay thermal ice suppression test.*

An environmental evaluation study of the thermal ice suppression demonstration project in Saginaw Bay was requested by the Environmental Evaluation Work Group.

The Great Lakes Fishery Laboratory of the U.S. Fish and Wildlife Service contracted to conduct the evaluation. The study period began in 1972 and ran to 1976. Its primary objective was to collect appropriate biological data in order to evaluate the effects of the thermal release on seasonal abundance and species composition of fish and benthic organisms in the area that would be influenced by the project. Benthic



*An-water thermograph in the St. Marys River.*

macro-invertebrates were selected because of their importance to the fishery, their relatively low mobility and stable community structure, and their high sensitivity to environmental changes.

Emphasis was placed on yellow perch because of the high fishery value of this species in Saginaw Bay and because a previous EPA study suggested that exposure of adult perch to elevated winter water temperatures could adversely affect their production of eggs and fry. Benthic invertebrates were sampled during ice-free periods before and after the demonstration of the thermal ice suppressor. Fish were sampled before, during and after the release of heated water.

A sample of 18 species of benthos was taken in the study area, consisting primarily of oligochaetes and chironomids. These were the only two that could be treated statistically. A total of 27 species of fish was collected during the course of the study. Yellow perch was one of the most abundant species collected. Difficulties were experienced in collecting sound

biological data due to a reduction of the length of the test system, and due to unfavorable weather and lake conditions. This resulted in the abandonment of numerous sampling stations and the establishment of new locations throughout the study. Only a few stations, therefore, survived the entire study period.

From usable data collected by the Fish and Wildlife Service during the Saginaw Bay thermal ice suppression test, the density of some food chain organisms (chironomids) was found to differ significantly between years. But within any given year the densities in areas receiving heated water did not differ markedly from those located in the unheated control areas.

An interesting observation was made with regard to the density of chironomids between the shipping channel and the bay floor areas. The density of organisms was found to be significantly more abundant on the shipping channel floor. One reason for this may be that the bottom substrate of the shipping channel has a higher organic content, which has been carried in by the polluted waters of the Saginaw River, than that of the bay floor substrate, which is more sandy.

Overall, statistical evidence did not show changes in species composition and abundance of fish in the study area. The study, however, was of short duration. Operational changes also were made in the test, and the study area probably was influenced by the polluted waters of Saginaw River, which may have overshadowed any subtle effect on fish that could be attributed to the release of heated water from the ice suppressor. In summary, the effects found, while measurable and statistically significant, cannot be labeled as either beneficial or adverse.

*Climatological investigations in the Lake Erie-Niagara River region*

A meteorological station was installed and monitored by the Buffalo District Corps of Engineers to determine the effects on local climatology of the ice boom installed each winter at the head of the Niagara River. In addition, two stations for the collection of solar radiation data were established at Port Maitland, Ontario, and Erie, Pennsylvania. Data collected from these stations included solar radiation measurements, temperature and humidity on a 24-hour basis, maximum and minimum temperature for daily calibration of a thermograph, average one-hour wind speeds and directions, and precipitation.

To gain insight into processes of ice formation and dissipation in the eastern end of Lake Erie an historical analysis was undertaken. Considered were: (1) the date of maximum summer water temperatures; (2) the date of 39° F water temperature in the fall; (3) the date of 32° F water temperature in the winter; (4) the date of 5-day average temperatures greater than 35° F; and (5) the date of 33° F water temperature in the spring for the pre-boom years 1935-36 and 1956-57 through 1963-64, and the post boom years 1964-65 through 1972-73.

Water temperature regimes which existed prior to boom installation, and those subsequent to installation, were compared by means of an inspectional analysis of the temperature record and detailed statistical analyses of the data. Water temperature data used were obtained from the Colonel Ward Filtration Plant at a depth of 18 feet at the Plant's water intake. Measurements were taken with a mercury-in-glass indicating thermometer since 1926 and a continuous recording device installed in 1959.

Analysis of data from the meteorological station near the Niagara River ice boom resulted in no effects detected on local climatology.

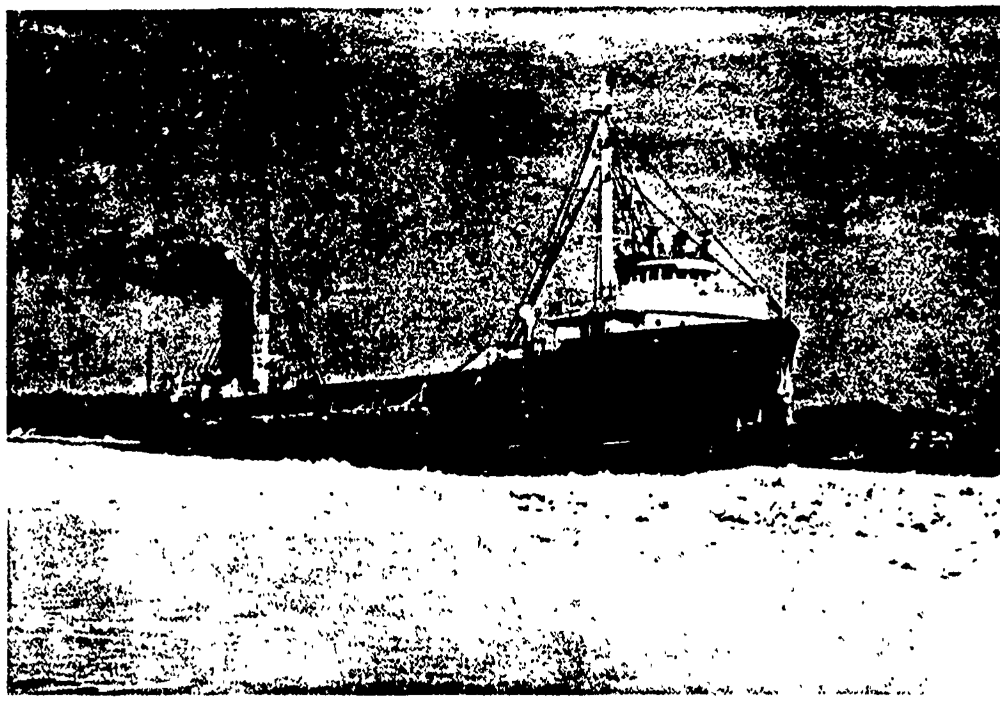
*Transport of oil and hazardous materials*

The Council of Environmental Quality (CEQ) Hazardous Materials Plan and the Coast Guard's Contingency Plan are effective and functioning programs for the recovery of hazardous substance spills.

The Coast Guard's Regional Contingency Plan is supportive of and supplements the CEQ Plan. Both materials and techniques used by the Coast Guard are the best currently available.

Should a spill occur during transport by water of many hazardous materials, the cost for clean-up is borne primarily by the owner of the facility which spilled the material. Financial responsibility is limited, however, and if clean-up costs exceed this limit, a "super fund" established by the Coast Guard, supplies remaining costs. Legislation is under review which will increase the financial liability of the owner to avoid excessive depletion of the Coast Guard fund.

Under the National Oil and Hazardous Substances Contingency Plan, the Coast Guard bears primary responsibility for coping with actual and potential spills. The Coast Guard has stated that the probability of a spill in winter is reduced for the following reasons. When vessel traffic continues through an extended season, tracks are established by preceding



*Oil tanker underway in heavy ice.*

ships and the risk of collision or grounding is less. Vessels moving through ice are not able to move at high rates of speed; they are not able to move out of their tracks with ease; when they do start to get out of track, it is relatively easy to stop them because of the frictional effect of ice There are a reduced number of vessels operating, and generally they are operating with an escort when they are in difficult waters; with lake waters completely or largely covered by ice, the effects of wind and waves are considerably reduced; and ice between ships tends to serve as a buffer to keep vessels away from danger.

If a spill should occur, ice and cold weather could affect containment operations, as well as oil recovery from stranded or sunken vessels. Effects of ice and cold weather can be either beneficial or adverse depending on a given set of circumstances. These and other considerations are important to contingency planning Unfortunately, there is little experience on which to focus, and each event is unique and requires its own approach, its own equipment, and its own solution.

A recently completed survey of cold regions oil spill mitigation technology included a cursory determination of the applicability of presently available means to the problems of detection, containment, recovery, temporary storage, and disposal of oil spilled in cold regions characterized by the existence of low temperatures and the presence of ice in many forms. The evaluations were based upon the experience of various persons conducting cold regions laboratory and field programs, and the experience of others in cold regions as reported in the technical literature. The survey revealed that a very limited degree of oil spill response capability is available for use in cold regions based upon the techniques and equipment currently employed in warmer climates. While this limited capability is available, a great deal of development work must be undertaken before a total cold regions oil spill response capability is available. Current technology falls short of the desired total response capability in all functional areas, including remote sensing, containment, recovery, temporary storage and disposal.

Should oil and hazardous material spills occur in an ice environment, special problems would include inadequacies in cleanup equipment, personnel, and

logistics inherent in the season and expanse of territorial occurrence. Yet, within four hours from initial notification, specially trained teams and the most sophisticated available containment, transfer, and cleanup equipment could be available at the nearest suitable airport in the Great Lakes. A river system, however, could pose additional problems due to the water regime and potential for rapid dispersion of the pollution.

The system and equipment currently in use by the Coast Guard represent a great improvement over past capability and are the best available for combatting oil and hazardous substance spills. The U.S. Fish and Wildlife Service has indicated the needs of fish and wildlife resource protection require improved capability in handling spills in fluvial waters and during winter conditions. The Coast Guard will continue research and development efforts in the field, including the requirement for double hulls on vessels carrying oil or hazardous material.

## Identification of social impact

*Social Effects Work Group Report*

The examination of the social aspects of navigation season extension was compiled by the Great Lakes Basin Commission under the direction and guidance of the Social Effects Work Group of the Winter Navigation Working Committee.

The objective of their study was to identify and review significant social effects of winter navigation season extension activities, to recommend solutions on further investigations, and to prepare a plan of action to address unresolved concerns, including both perceived and real dimensions of social effects.

The study was carried out in three stages. The first consisted of a literature research to identify the known and documented social effects of winter navigation, and to record any actions taken to resolve these concerns. The second involved the identification of potential and previously unidentified social effects through public meetings and interviews, and the third was the preparation of a plan of action to address unresolved concerns and to suggest further investigations.

The Social Effects Work Group identified in its report, *The Social Aspects of Winter Navigation*, four major areas of social effect: (1) recreation; (2) shore erosion and structural damage; (3) cross channel transportation; and (4) occupational groups.

*St. Marys River Recreation Study*

This study was conducted in conjunction with the Heritage Conservation and Recreation Service and Lake Superior State College to determine the effect of winter navigation on recreation -- primarily fishing and snowmobiling on the St. Marys River. The study was conducted at eleven major winter recreation sites along the navigation channel from Whitefish Point to DeTour Passage-Drummond Island and involved on-site observations and personal interviews of recreation participants.

The final result of the St. Marys River recreational study was that nearly one-third of the people interviewed indicated that extended navigation affected the quality of their recreational activity, primarily in ice fishing and snowmobiling. The majority of negative comments came from snowmobilers who were concerned with unsafe ice conditions.

*Shore erosion and dock damage monitoring*

Complaints of shore and dock damage by owners of property along the navigation channels of the St. Marys River have come about as a result of the extension of the navigation season. An extensive study that involved identification of both erosion and dock damage was conducted. Specific docks were selected from each study area and visually inspected and photographed throughout the winter to detect movement or damage.

Similarly, a total of 12 profile sites were established in erosion-prone areas. Profiles were systematically remeasured over a 2½ year period to document any changes that may have occurred between stable shore and out into the 2-3 foot depth in the river. Ship-wave measurements were also taken during both ice and open water conditions to aid in the study.

That winter navigation does contribute to increased dock damage in certain areas of the St. Marys and St. Clair Rivers was indicated as a result of studies on these subjects. The studies indicated damage arising primarily from ice moving laterally and/or vertically against the structures.

*Island transportation access efforts*

*Sugar Island activities:* One of the major problems associated with winter navigation in the St. Marys River is the disruption of traditional modes of transportation between the islands and the mainland.

At the upstream end of Little Rapids Cut in the St.

Marys River, just below Soo Harbor, is located the Sugar Island ferry crossing. River currents at this point tend to keep the area relatively ice free through much of the winter. However, winds or thaw conditions will occasionally loosen ice in the harbor, which flows downstream to jam the Cut. Before the Winter Navigation Demonstration Program, this was an infrequent occurrence and would temporarily hamper ferry operation until the ice stabilized and the ferry track was reopened.

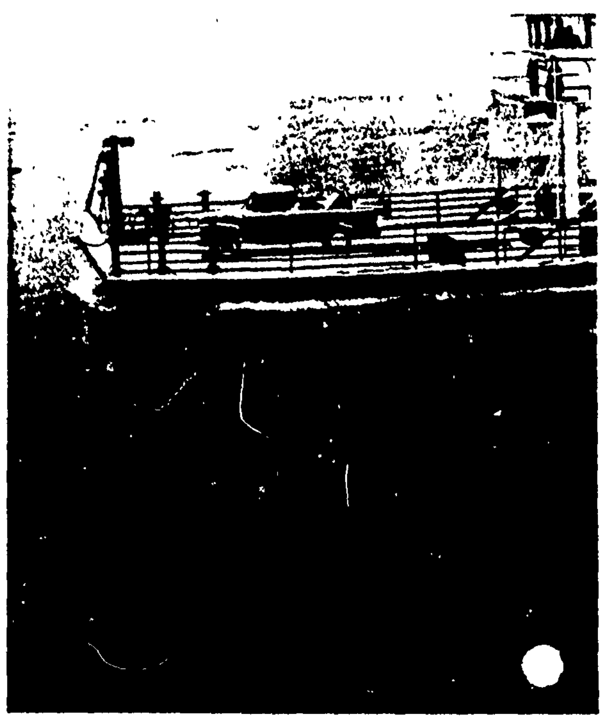
The ice cover in the Soo Harbor was disrupted by ship transit during the Winter Navigation Program, resulting in loose ice frequently filling the Cut and occasionally halting ferry operations until icebreakers could reopen the crossing area.

Modifications to the Sugar Island ferry were made to see if the ice operating capabilities of the ferry could be improved. Improvements included changing the shape of the bow at both ends and doubling the thickness of hull plates near the water line. The strength of the hull was also increased by adding plates to the side and installing longitudinal side girders. The vessel was repowered with two 300 horsepower engines, replacing the existing 100 horsepower engines. Also included were a new shaft, bearings, propellers, and a strengthened rudder. The new ice strengthened hull and more powerful engines were effective in allowing the ferry to operate through moving ice floes.

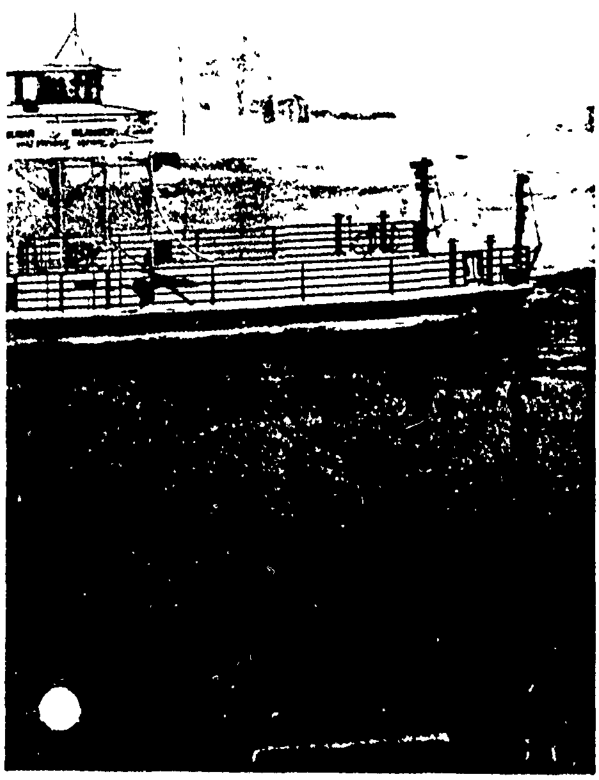
As mentioned previously, model studies and a prototype ice boom test were performed for the Little Rapids Cut to see if the ice cover could be stabilized and allow vessel transits. Since the annual installation of an ice boom in 1975, there has been no serious disruptions to ferry operation.

To assist the ferry in reaching the mainland docks, an air bubbler-flusher system was installed and operated each year. The system flushed ice away from the dock providing there was an area out in the channel into which the ice could be flushed.

To help maintain the transportation link at the Sugar Island ferry crossing, an operational plan was developed and implemented during the fourth through eighth years of the program. The U.S. Coast Guard Captain of the Port (Soo) was designated as Officer-in-Charge to coordinate and implement the operational plan efforts. The Coast Guard and a private tug performed preventative icebreaking in the area. In the event the ferry was temporarily unable to operate, Coast Guard vessels were used to provide transportation. If the National Weather Service's experimental forecasts indicated ferry service would be interrupted in excess of five consecutive days, shipping through the area would be halted until the area cleared enough to resume ferry operations.



*Sugar Island Ferry moves across St. Marys River.*



*Lime Island airboat.* Navigation season extension activities resulted in the disruption of the solid ice cover between Lime Island and the mainland. An airboat, capable of crossing solid or broken ice and open water was designed and constructed to provide transportation during the extended season.

A number of improvements were suggested by airboat users, including a new engine and propeller, a walk-through windshield, new passenger seats, canvas top and side curtains for the passenger compartment, and a sturdier engine mount.

The test airboat has not been accepted by the residents as an effective solution. They claim the vehicle is uncomfortable and inconvenient. The vehicle is old and if extended season navigation were to continue, a newer vehicle would be required.

*Closed West Neebish Channel:* During the open water season, upbound traffic uses the Middle Neebish Channel and downbound traffic transits the straighter West Neebish Channel. The Neebish Island ferry operates across the West Neebish Channel above a narrow excavated channel commonly called Rock Cut. When ice thickness is sufficient to support foot and snowmobile traffic, the West Neebish Channel is closed to navigation. The ferry service shuts down for the winter and both upbound and downbound navigation use the Middle Neebish Channel. Access to Neebish Island is across the ice until ferry service is resumed in the spring.

Various solutions are being investigated to provide access to the Island if the West Neebish Channel should be opened to winter navigation. However, the West Neebish Channel is not included in the proposed plan for winter navigation.

*Monitored Drummond Island crossing:* The Drummond Island ferry operates year-round across the mile-wide DeTour Passage, located where the St. Marys River flows into Lake Huron. Because ferry operators complained of unusually heavy ice floes and navigation problems shortly after the beginning of the Demonstration Program, a monitoring program was established to observe winter operations of the ferry.

A time-lapse movie camera was set up to record daily ferry operations throughout several winters. Aerial photos were taken to document the changing ice conditions, and a Corps observer made periodic crossings on the ferry, discussed operations with the ferry operators, and obtained copies of the daily crossing logs.

Results of the observations indicate that the extended navigation activities did not contribute to Drummond Island ferry problems. The problems arise

because the ferry has marginal ice operating capabilities and faces difficulty maneuvering in ice floes blown against shoreline docking facilities. The continuously maintained ship track, through the ice bridge upstream of the ferry crossing, severs the alternate means of transportation to the mainland (over the ice) when the primary means (the ferry) is out of service for repairs. This situation would continue to be monitored during any operational season to determine if there is any change in this situation.

*St. Clair River:* As part of the Detroit Districts Winter Operation Reporting Center operations a close watch was kept on all cross channel river traffic in the St Clair and Detroit Rivers. It was determined that the impact of winter navigation on cross-channel transportation service is minimal.

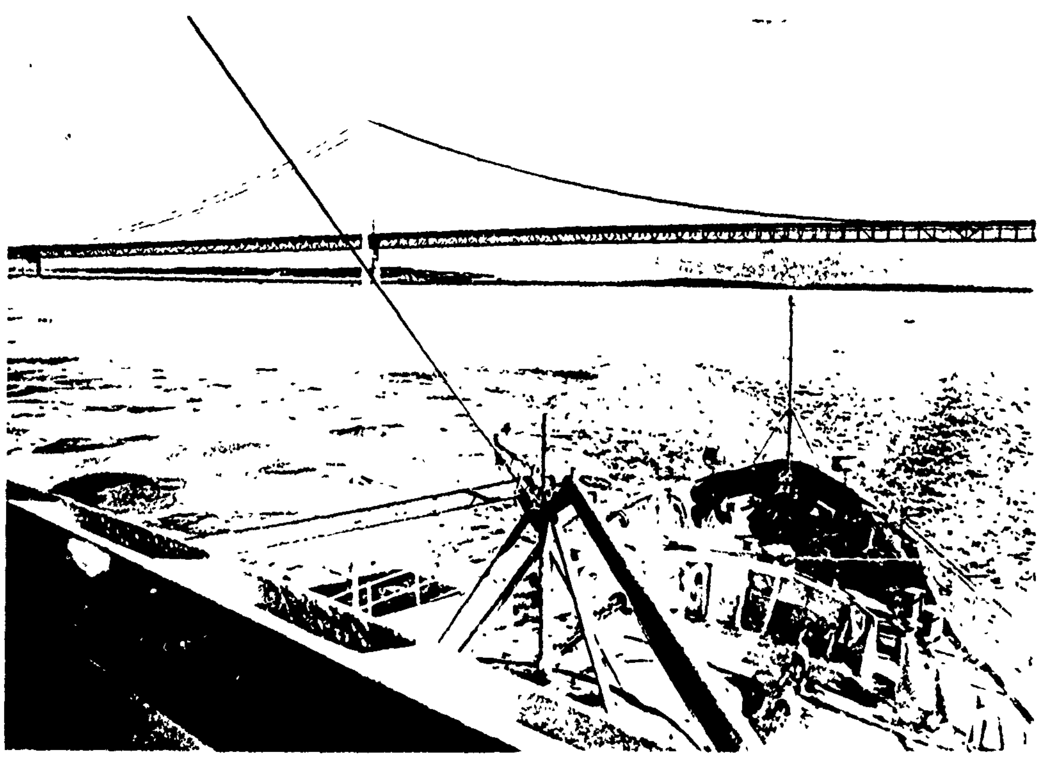
The Harsens Island ferry, operating between Algonac, Michigan and Harsens Island on the north channel of the St. Clair River has experienced interruptions in service for short periods of time (1 to 4 days) during the 1978-79 winter season. This is an area of naturally occurring ice jams of substantial proportion. This area would also be monitored during an operational season to determine if navigation increases these effects.

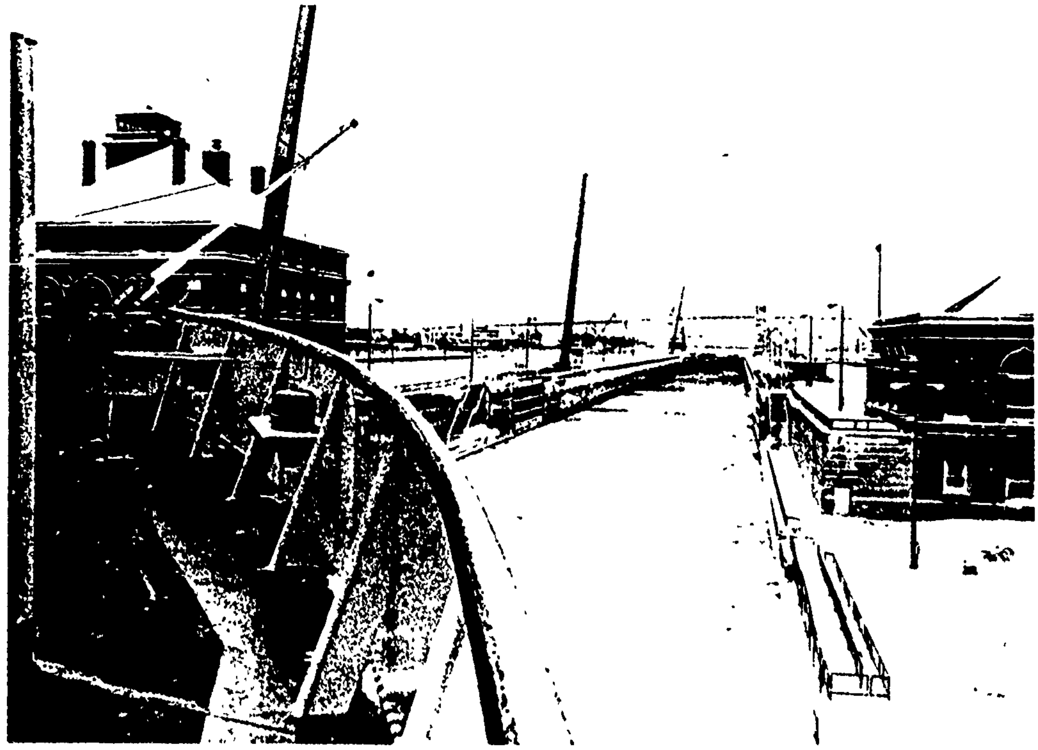
The Drummond Island and Harsens Island transportation issues remain unresolved and further studies are necessary.

*Sociological Assessment Study by MARAD*

The Maritime Administration (MARAD) con-

*Vessel transits Straits of Mackinac.*





*Upbound through Soo Locks.*

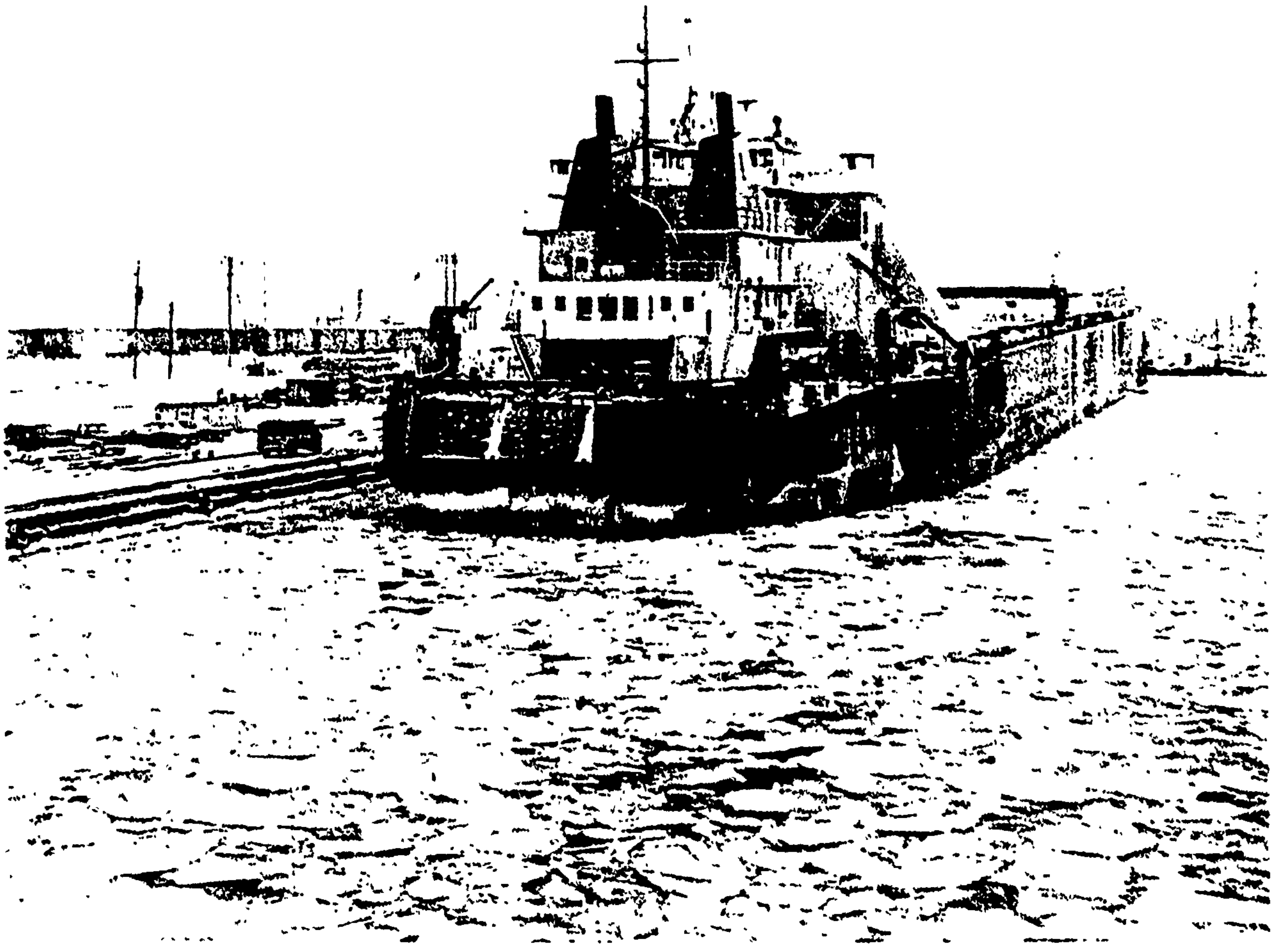
cluded a study in October 1976 aimed at identifying significant psychological problems and benefits of an extended winter navigation season on Great Lakes personnel. The study was entitled, "Sociological Assessment Survey" (SAS) A questionnaire was developed and directed to representative samples of Great Lakes industry groups, i.e., vessel, terminal, lock, and pilot personnel Almost 1,700 questionnaires were distributed with a high response rate of approximately 46 percent

Four occupational groups have been identified as being directly affected by winter navigation activities personnel employed by vessels, terminals, locks and as pilots The effects on these groups are primarily two individual comfort and the psycho-socio effects of an extended season The results of the Maritime Administration Sociological Assessment Survey are summarized below.

*Vessel personnel* Although these individuals have positive attitudes toward their jobs, they appear somewhat negative with regard to the extended season. They are concerned about safety during the winter, feeling the need for more time off, indicating that sailing during the extended season is disturbing to their families. The group did exhibit a positive attitude in situations where individuals either sailed voluntarily or knew several months in advance that they would be sailing during the extended season. Serious psycho-socio problems related to extension are anticipated with this group, although several suggestions were made to improve season extension acceptance.

*Lock and terminal personnel* While virtually all lock and many terminal personnel were positive toward an extended season, union terminal personnel exhibited more negative attitudes than non-union terminal workers. The group provided suggestions aimed at improving conditions relating to winter navigation. As with other groups, they asked for more information

*Presque Isle works under winter conditions.*



concerning the extension. Different segments of this group seemed to prefer particular job assignments, although not necessarily the most easy or comfortable ones. These preferences should be honored or retraining should be initiated to accommodate them

Finally, some personnel (union members) expressed less job satisfaction and less positive attitudes toward extension than non-union members. It would be helpful to solicit suggestions from these union members regarding their season extension concerns

*Pilot personnel:* Some tentative suggestions may be made regarding this group, although few responses were received. Initially, this group needs more extensive information on season extension. Suggestions from the group should be actively solicited. The possibility of having more pilots available during the extended season should be explored.

Pilots should be better informed about upcoming changes in their work schedules and be allowed to provide input or discussion about these changes. The use of volunteers is also suggested. Vacation schedules should be altered to allow pilots to take vacations during summer months.

*Winter Cargo Handling Study*

The Great Lakes Regional Office of MARAD conducted a study, entitled "The Effects of Winter Weather on Cargo Handling Productivity," as an in-house project. The objective of the study was to determine the effects of adverse winter weather on cargo handling productivity at Great Lakes Ports and terminals, to analyze these effects, and to make recommendations on methods or techniques (if any) which would improve productivity to the degree that the competitive posture of Great Lakes Ports would be improved.

The results of the study on the effect of winter weather on cargo handling productivity is based on a survey of terminal operators, shipping lines and labor organizations in the Great Lakes area. The consensus of the survey indicated that the effects of winter weather did not have a severe impact on cargo handling operations, with the exception of bulk coal loading and unloading. This commodity has been identified for further study due to the intermodal aspects and the nature of the cargo itself.

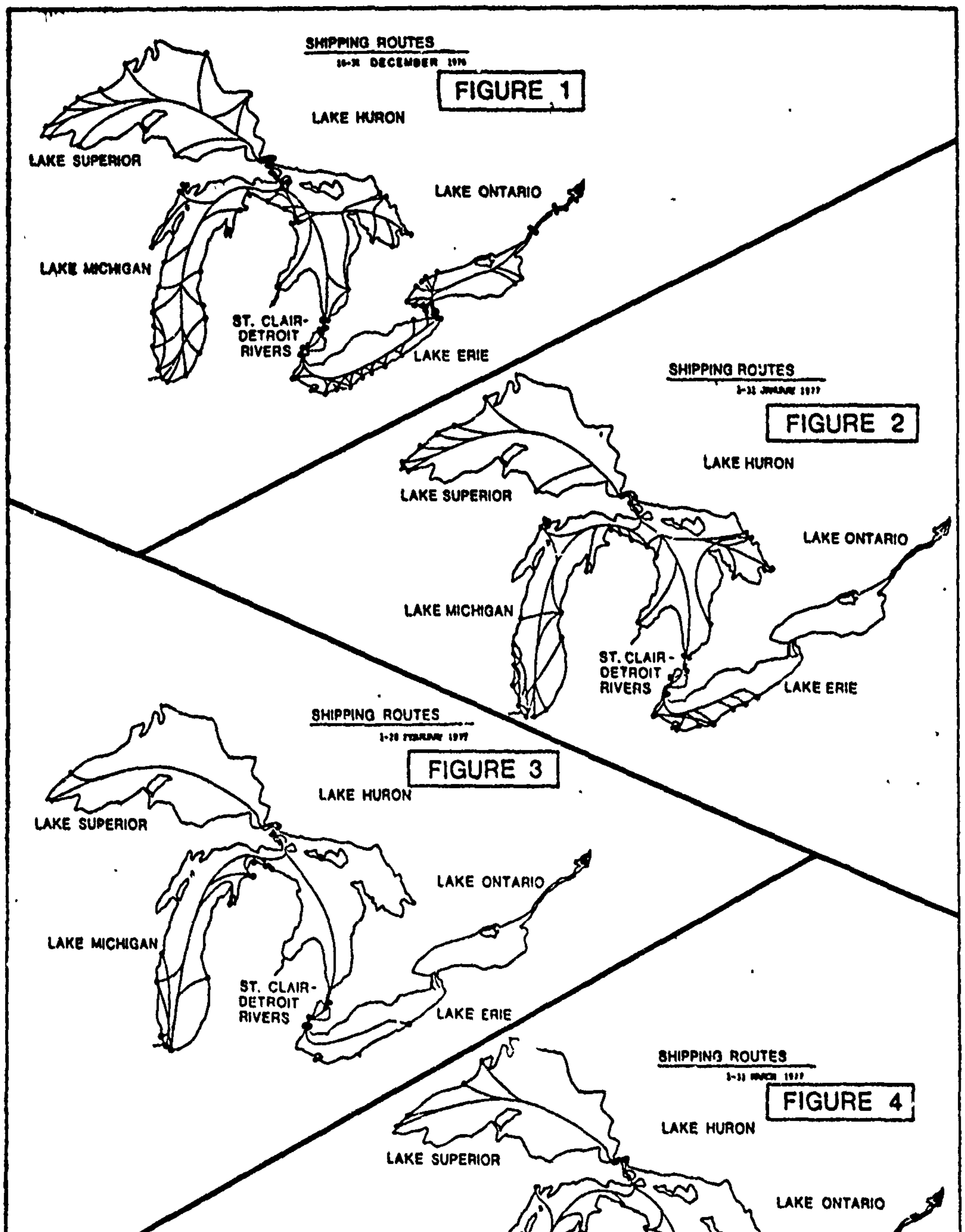
Other specific findings of the study indicated that winter weather was not significantly detrimental to productivity as long as safety considerations were applied and adequate winter clothing was made available at a moderate cost to employees. Standardized or issued cold-weather clothing was not seen to be an alternative either by labor or management, due to the variance in individual taste and desires.

Work stoppages during winter were seen as being no more frequent than those caused by summer rain storms. Benefits to labor and to ports in terms of year-round employment would occur as a result of the extension effort, with no degradation of experienced personnel.

Benefits from increased revenues would offset equipment maintenance costs; very little special equipment (except for snow removal equipment) would be needed. Most ports currently consider themselves to be operational on a year-round basis already, due to transshipment requirements.

This study applies particularly well to winter navigation, since it resolves the issue of the capability of Great Lakes ports and terminals to operate during the winter season, should such operations become a reality.

*Shipping routes, winter of 1976-77.*



*Traffic study*

The primary activity undertaken by the Economic Evaluation Work Group during the Demonstration Program was a Traffic Study of all commodities shipped on the Great Lakes during each year of the Program. An origin-destination traffic matrix was prepared for each year of extended season traffic based on data obtained from Soo Locks records, from vessel operation reports of U.S. companies that ship on the Great Lakes, and from a telephone/mail survey of Canadian companies that ship on the Lakes.

The results of the Traffic Study are depicted in Table I for FY 72-78 (FY 79 data have not yet been completed). As shown in Part A of Table I, the total net tonnage handled on the Great Lakes during the extended navigation season increased steadily from 3.6 million tons in FY 72 to 15.0 million tons in FY 75, then decreased annually to 5.3 million in FY 77, before increasing again in FY 78 to 9.1 million tons.

Iron ore accounted for a record 74 percent of all commodities shipped during the FY 78 extended season (due primarily to the iron ore mine workers' strike in 1977 forcing companies to ship more ore during the 1977-78 winter) and maintained its position as the primary commodity shipped from FY 72 through FY 78 (Table I, Part B). Net tonnage by Lake of origin is shown in Part C of Table I. During each of the extended seasons, Lake Superior has been the major Lake of origin. Part D of Table I illustrates the fact that Lake Michigan was the major lake of destination in the FY 78 extended season, as it has been in every year except FY 73.

Overall, Parts A, B, C, and D show that the primary extended season commodity movement during the Demonstration Program has been iron ore originating out of Lake Superior and destined for Lake Michigan, Lake Erie, and the St. Clair-Detroit Rivers System.

Figures 1 through 4 show the typical Great Lakes shipping routes for each month of extended season operation, based on the Demonstration Program tonnages contained in Table I. As can be evidenced from these figures, traffic movements are heaviest in December, then gradually decline in January and February, and increase again in March as the winter season comes to a close.

Table II shows the opening and closing dates, transits and tonnage for the Soo Locks for the 1967-1978 extended navigation seasons. As this table shows, the Soo Locks have remained open all year for the past five winters (although, from 23 January 1977 to 17 March 1977 the Demonstration Program was suspended). A record 9,134,539 tons of commerce passed through the locks during the 1974 extended season, while 1977 was the second highest year with 6,844,222 tons and 1978 the third highest year with 6,629,598.

A summary of the market value of the annual waterborne commerce passing through the Soo Locks during the 1971-1978 extended navigation seasons is shown in Table III. This table also points out the fact that the average annual amount of tonnage moving through the Soo Locks during the 1971-1978 extended navigation season period was 5,165,900 tons with an average annual market value of $300,231,100. (This figure indicates market value and not savings gained by an extended navigation season). It should be noted that the market values of the various tonnages displayed in Table III do not include the transport costs that would be associated with moving these goods from the point of origin to the point of destination. As an example, the total transport cost to rail iron ore (the primary commodity shipped during the Demonstration Program) from the Mesabi range to Duluth-Superior and then transship it by vessel to a Lake Erie port would be approximately $9.54 per ton. This $9.54 per ton includes all dock and handling charges, and represents nearly one-fourth of the $37.50 per ton market value of iron ore shown in Table III.

**TABLE I**
**COMPARISON OF FY 72 THROUGH FY 78**
**GREAT LAKES EXTENDED NAVIGATION SEASONS**

**Part A**
**TOTAL NET TONNAGE[1]**

**NET TONS**

| Commodity | FY 72 | FY 73 | FY 74 | FY 75 | FY 76 | FY 77 | FY 78 |
|---|---|---|---|---|---|---|---|
| Iron Ore | 1,175,967 | 3,900,872 | 4,927,019 | 8,399,424 | 5,493,064 | 2,569,129 | 6,733,582 |
| Grain | 709,679 | 623,752 | 1,099,289 | 1,712,258 | 1,289,297 | 775,177 | 947,557 |
| Coal | 1,127,263 | 663,891 | 1,654,906 | 2,229,582 | 1,685,214 | 870,525 | 513,204 |
| Stone | 140,516 | 493,886 | 1,117,092 | 1,140,778 | 509,019 | 231,649 | 319,137 |
| Petroleum | 368,341 | 757,728 | 985,052 | 1,015,124 | 590,542 | 607,675 | 407,849 |
| Others | 55,589 | 294,095 | 845,241 | 516,396 | 96,488 | 237,042 | 164,661 |
| TOTALS | 3,577,355 | 6,734,224 | 10,628,599 | 15,013,562 | 9,663,624 | 5,291,197 | 9,085,990 |

1 Reflects total net tonnage moved on the Great Lakes-St. Lawrence Seaway system as opposed to tonnage moved through the Soo Locks

**INDEX OF CHANGE: FY 72=100**

| Commodity | FY 72 | FY 73 | FY 74 | FY 75 | FY 76 | FY 77 | FY 78 |
|---|---|---|---|---|---|---|---|
| Iron Ore | 100 | 332 | 419 | 714 | 467 | 218 | 573 |
| Grain | 100 | 88 | 155 | 241 | 182 | 109 | 134 |
| Coal | 100 | 59 | 147 | 198 | 150 | 77 | 46 |
| Stone | 100 | 351 | 795 | 812 | 362 | 165 | 227 |
| Petroleum | 100 | 206 | 267 | 275 | 160 | 165 | 111 |
| Others | 100 | 529 | 1,520 | 929 | 174 | 426 | 296 |
| TOTALS | 100 | 188 | 298 | 420 | 270 | 148 | 254 |

**TABLE I (continued)**
**Part B**
**TOTAL NET TONNAGE BY COMMODITY**

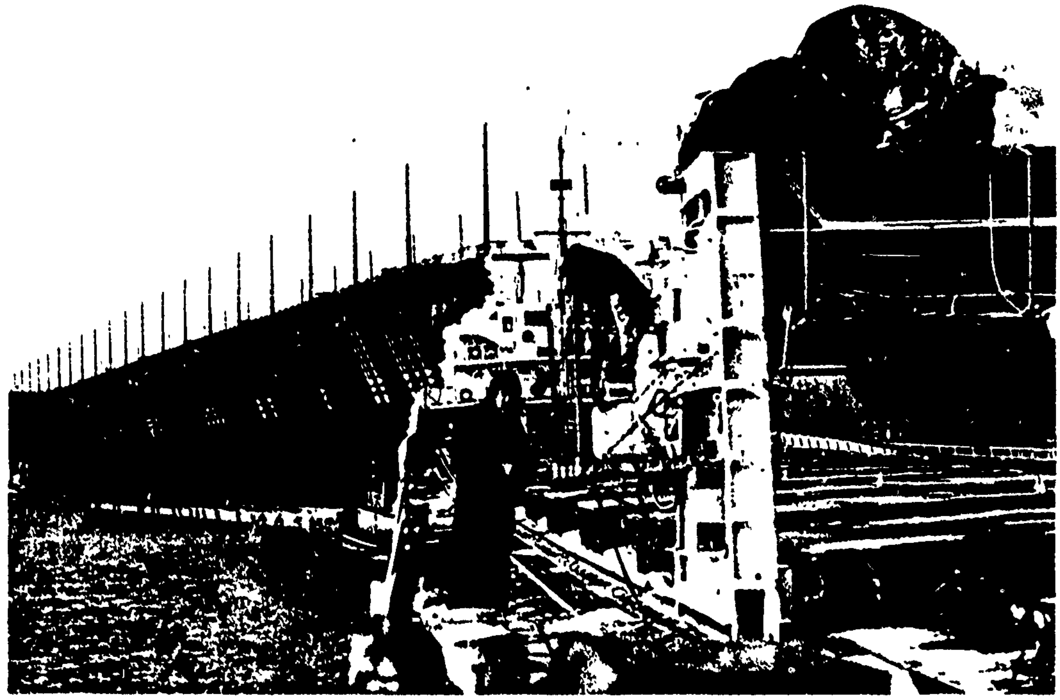
**% of Total Net Tonnage**

| Commodity | FY 72 (3,557,355) | FY 73 (6,734,224) | FY 74 (10,628,599) | FY 75 (15,013,562) | FY 76 (9,663,624) | FY 77 (5,291,197) | FY 78 (9,085,990) |
|---|---|---|---|---|---|---|---|
| Iron Ore | 33% | 58% | 46% | 56% | 57% | 49% | 74% |
| Grain | 20 | 9 | 10 | 11 | 13 | 15 | 10 |
| Coal | 31 | 10 | 16 | 15 | 18 | 16 | 6 |
| Stone | 4 | 7 | 11 | 8 | 5 | 4 | 4 |
| Petroleum | 10 | 12 | 9 | 7 | 6 | 11 | 4 |
| Others | 2 | 4 | 8 | 3 | 1 | 5 | 2 |
| TOTALS | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

**Part C**
**TOTAL NET TONNAGE BY LAKE OF ORIGIN**

**% of Total Net Tonnage**

| LAKE OF ORIGIN | FY 72 (3,577,355) | FY 73 (6,734,224) | FY 74 (10,628,599) | FY 75 (15,013,562) | FY 76 (9,663,624) | FY 77 (5,153,561) | FY 78 (9,085,990) |
|---|---|---|---|---|---|---|---|
| Lake Superior | 54% | 56% | 48% | 61% | 59% | 55% | 75% |
| Lake Michigan | 9 | 24 | 21 | 11 | 16 | 13 | 10 |
| Lake Huron | 3 | 5 | 9 | 7 | 4 | 4 | 5 |
| St. Clair-Detroit Rivers | 1 | 2 | 5 | 3 | 2 | 8 | 3 |
| Lake Erie | 32 | 12 | 16 | 16 | 18 | 19 | 6 |
| Lake Ontario | 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| TOTALS | 100% | 100% | 100% | 100% | 100% | 100% | 100% |



*Winter activity.*

**TABLE I (continued)**
**Part D**
**TOTAL NET TONNAGE BY LAKE OF DESTINATION**

% of Total Net Tonnage

| LAKE OF DESTINATION | FY 72 (3,463,470) | FY 73 (6,700,408) | FY 74 (10,594,578) | FY 75 (14,113,239) | FY 76 (9,568,327) | FY 77 (5,291,197) | FY 78 (9,030,249) |
|---|---|---|---|---|---|---|---|
| Lake Superior | 3% | 3% | 3% | 7% | 5% | 8% | 8% |
| Lake Michigan | 36 | 36 | 35 | 31 | 39 | 40 | 47 |
| Lake Huron | 5 | 3 | 6 | 6 | 6 | 5 | 6 |
| St. Clair-Detroit Rivers | 23 | 17 | 24 | 18 | 11 | 19 | 4 |
| Lake Erie | 11 | 37 | 23 | 25 | 28 | 11 | 25 |
| Lake Ontario | 22 | 4 | 9 | 13 | 11 | 17 | 10 |
| TOTALS | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

*Moving toward the Soo Locks.*

**TABLE II**
**SOO LOCKS TRANSITS AND TONNAGE**
**AFTER NORMAL SEASON CLOSING DATE (DECEMBER 16)**

| Season | Opening Date | Closing Date | Transits[1] UP | DN | TT | Tonnage |
|---|---|---|---|---|---|---|
| 1967 | 1 April 67 | 31 Dec 67 | 15 | 25 | 40 | 398 978 |
| 1968 | 1 April 68 | 4 Jan 69 | 22 | 32 | 54 | 471 542 |
| 1969 | 1 April 69 | 11 Jan 70 | 37 | 56 | 93 | 1 020 050 |
| 1970 | 1 April 70 | 29 Jan 70 | 66 | 86 | 152 | 1 423 612 |
| 1971 | 1 April 71 | 1 Feb 72 | 86 | 107 | 193 | 1 976 407 |
| 1972 | 1 April 72 | 8 Feb 73 | 144 | 179 | 323 | 3 362 974 |
| 1973 | 1 April 73 | 7 Feb 74 | 192 | 226 | 418 | 4 780 003 |
| 1974 | All Year | | 368 | 395 | 763 | 9 134 539 |
| 1975 | All Year | | 210 | 233 | 443 | 5 664 689 |
| 1976 | All Year | | 119 | 131 | 250 | 2 938 011 |
| 1977 | All Year | | 279 | 297 | 576 | 6 844 222 |
| 1978 | All Year | | 252 | 284 | 536 | 6 629 598 |

[1] UP indicates upbound, DN indicated downbound, and TT indicates total transits

## TABLE III

### MARKET VALUE OF WATERBORNE COMMERCE PASSING THROUGH THE SOO LOCKS DURING NAVIGATION EXTENDED SEASONS 1971-1978

| Ext. Sea. Yrs | IRON ORE | COAL | STONE | GRAIN | PETROLEUM PRODUCTS | OTHER BULK 2/ | GENERAL CARGO 3/ | TOTAL |
|---|---|---|---|---|---|---|---|---|
| **1971** | | | | | | | | |
| NET TONS 1 | 1,136,971 | 62,566 | - | 709,679 | 16,741 | 16,858 | 33,592 | 1,976,407 |
| AVG VALUE PER TON | $ 37.50 | 29.95 | - | 129.58 | 129.86 | 10.00 | 484.00 | |
| TOTAL MARKET VALUE | $ 42,636,400 | 1,873,900 | - | 91,960,200 | 2,174,000 | 168,600 | 16,258,500 | $155,071,600 |
| **1972** | | | | | | | | |
| NET TONS 1 | 2,673,947 | 61,959 | - | 553,424 | 8,885 | 12,366 | 52,393 | 3,362,974 |
| AVG VALUE PER TON | $ 37.50 | 29.95 | - | 129.58 | 129.86 | 10.00 | 484.00 | |
| TOTAL MARKET VALUE | $100,273,200 | 1,855,700 | - | 71,712,700 | 1,153,800 | 123,700 | 25,358,200 | $200,477,100 |
| **1973** | | | | | | | | |
| NET TONS 1 | 3,674,433 | 103,331 | 20,508 | 925,377 | 9,337 | 16,767 | 30,250 | 4,780,003 |
| AVG VALUE PER TON | $ 37.50 | 29.95 | 2.08 | 129.58 | 129.86 | 10.00 | 484.00 | |
| TOTAL MARKET VALUE | $137,791,200 | 3,094,800 | 42,700 | 119,910,400 | 1,212,500 | 167,700 | 14,641,000 | $276,860,300 |
| **1974** | | | | | | | | |
| NET TONS 1 | 6,889,452 | 563,116 | 62,317 | 1,487,298 | 18,671 | 43,709 | 69,976 | 9,134,539 |
| AVG VALUE PER TON | $ 37.50 | 29.95 | 2.08 | 129.58 | 129.86 | 10.00 | 484.00 | |
| TOTAL MARKET VALUE | $258,354,500 | 16,865,300 | 129,600 | 192,724,100 | 2,424,600 | 437,100 | 33,868,400 | $504,803,600 |
| **1975** | | | | | | | | |
| NET TONS 1 | 4,163,036 | 322,313 | - | 1,113,919 | 15,170 | 18,700 | 31,551 | 5,664,689 |
| AVG VALUE PER TON | $ 37.50 | 29.95 | - | 129.58 | 129.86 | 10.00 | 484.00 | |
| TOTAL MARKET VALUE | $156,113,900 | 9,653,300 | - | 144,341,600 | 1,970,000 | 187,000 | 15,270,700 | $327,536,500 |
| **1976** | | | | | | | | |
| NET TONS 1 | 1,991,407 | 105,567 | 34,502 | 669,143 | 58,820 | 21,700 | 53,872 | 2,935,011 |
| AVG VALUE PER TON | $ 37.50 | 29.95 | 2.08 | 129.58 | 129.86 | 10.00 | 484.00 | |
| TOTAL MARKET VALUE | $ 74,677,800 | 3,161,700 | 71,800 | 86,707,500 | 7,638,400 | 217,000 | 26,074,000 | $198,548,200 |

| Ext Sea Yrs | IRON ORE | COAL | STONE | GRAIN | PETROLEUM PRODUCTS | OTHER BULK 4/ | GENERAL CARGO 3/ | TOTAL |
|---|---|---|---|---|---|---|---|---|
| **1977** | | | | | | | | |
| NET TONS 1 | 5,643,722 | 77,877 | 39,987 | 859,109 | 155,454 | 16,807 | 51,266 | 6,844,222 |
| AVG VALUE PER TON | $ 37.50 | 29.95 | 2.08 | 129.58 | 129.86 | 10.00 | 484.00 | |
| TOTAL MARKET VALUE | $211,639,600 | 2,332,400 | 83,200 | 111,323,300 | 20,187,300 | 168,100 | 24,812,700 | $370,546,600 |
| **1978** | | | | | | | | |
| NET TONS 1 | 5,193,613 | 124,637 | 170,518 | 898,103 | 182,049 | - | 60,678 | 6,629,598 |
| AVG VALUE PER TON | $ 37.50 | 29.95 | 2.08 | 129.58 | 129.86 | - | 484.00 | |
| TOTAL MARKET VALUE | $194,760,500 | 3,732,900 | 354,700 | 116,376,200 | 23,640,900 | - | 29,368,200 | $368,233,400 |

## AVERAGE TONNAGE AND AVERAGE MARKET VALUE OF EXTENDED SEASONS 1971-1978

| 1971-1978 | IRON ORE | COAL | STONE | GRAIN | PETROLEUM PRODUCTS | OTHER BULK | GENERAL CARGO | TOTAL |
|---|---|---|---|---|---|---|---|---|
| NET AVERAGE TONS 1 | 3,920,800 | 177,700 | 41,000 | 902,000 | 58,100 | 18,400 | 47,900 | 5,165,900 |
| AVG VALUE PER TON | $ 37.50 | 29.95 | 2.08 | 129.58 | 129.86 | 10.00 | 484.00 | |
| TOTAL AVERAGE MARKET VALUE | $147,030,000 | 5,322,100 | 85,300 | 116,881,200 | 7,544,900 | 184,000 | 23,183,600 | $300,231,100 |

1 Source of market value per ton of cargo: Iron ore Skillings Mining Review, 25 August 1979; Coal Federal Energy Regulatory Commission 1979. Average contract price per ton for east and north central states; Stone Presque Isle Corporation, Long Lake, Michigan, 14 September 1979; Grain Wall Street Journal (cash prices), 23 January 1979; Petroleum products Wall Street Journal (cash prices), 23 January 1979; Other Bulk estimated based on product mix; General Cargo U S Department of Commerce, Bureau of Census, **Domestic and International Transportation of U.S. Foreign Trade**, 1976

2 Includes Paper and Woodpulp; Lumber, and Logs; and Non-Metallic Minerals.

3 Includes Miscellaneous Merchandise, Manufactured Iron & Steel, Pig Iron and Scrap Iron

## TABLE IV

## DISTRIBUTION OF DEMONSTRATION PROGRAM FUNDS COST (1) BY FISCAL YEAR

### ICE INFORMATION

| | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979(2) | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| **NOAA-Great Lakes Environmental Research Laboratory** | | | | | | | | | |
| (a) Air and water temperature measurements | $ 5.2 | $ 6.9 | $ 10.0 | $ 6.5 | $ - | $ - | $ - | $ - | $ 28.6 |
| (b) Lake Superior bathythermograph measurements | - | 11.0 | 6.0 | 6.5 | - | - | - | - | 23.5 |
| (c) Ice thickness measurements | 7.1 | 13.6 | 4.5 | 4.5 | - | - | - | - | 29.7 |
| (d) Aerial photography of selected areas | 17.7 | 24.0 | 4.0 | - | - | - | - | - | 45.7 |
| (e) St. Lawrence River freeze-up forecasts | - | 30.0 | 30.0 | - | - | - | 40.0 | 40.0 | 140.0 |
| (f) Harbor freeze-up forecasts | - | - | 20.0 | - | - | - | - | - | 20.0 |
| (g) Little Rapids Cut ice condition forecasts | - | - | 20.0 | - | - | - | - | - | 20.0 |
| **U.S. Coast Guard** | | | | | | | | | |
| (a) Operation of Navigation Center | 30.5 | 14.1 | 21.0 | 21.0 | 23.0 | 19.0 | 38.0 | 85.0 | 251.6 |
| (b) Coast Guard Ice Reconnaissance | 11.5 | 22.7 | 26.0 | 10.8 | 11.0 | - | - | - | 82.0 |
| **NOAA - National Weather Service** | | | | | | | | | |
| (a) Ice and weather forecast operations | 33.0 | 57.0 | 57.0 | 57.0 | 70.0 | 36.0 | 72.0 | 82.0 | 464.0 |
| (b) Short-Term ice forecast technique | - | 13.0 | 15.0 | - | - | - | - | - | 28.0 |
| (c) Harbor freeze-up and break-up forecasts | - | - | 20.0 | - | - | - | - | - | 20.0 |
| **St. Lawrence Seaway Development Corporation** | | | | | | | | | |
| St. Lawrence River Surveillance and monitoring | 50.0 | 40.0 | 55.0 | 125.0 | 120.0 | - | - | - | 390.0 |
| Document St. Lawrence River Ice conditions | - | - | - | - | - | - | 150.0 | - | 150.0 |
| **Corps of Engineers - Detroit District** | | | | | | | | | |
| (a) Ice thickness and movement measurement and water level fluctuations in St. Clair and St. Marys River | 65.0 | 53.7 | 50.8 | 23.8 | 7.2 | 9 | 14.9 | - | 216.3 |

## TABLE IV (continued)

| ICE INFORMATION (continued) | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979(2) | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| (b) Temperature profiles in selected areas | - | 5.0 | 2.8 | 3.4 | - | - | - | - | 11.2 |
| (c) Instrumentation of Pile movement and heaving - Great Lakes Area | - | - | - | 21.0 | - | - | - | - | 21.0 |
| (d) Whitefish Bay Pressure Wave Study | - | - | - | - | - | - | 7.8 | - | 7.8 |
| **Corps of Engineers - Buffalo District** | | | | | | | | | |
| Eastern Lake Erie ice surveillance activities | 13.0 | 7.0 | 12.0 | 4.8 | - | - | - | - | 36.8 |
| **U.S. Army Electronic Proving Grounds** | | | | | | | | | |
| Remote sensing of Lake ice conditions (SLAR) | - | - | 80.0 | - | - | - | - | - | 80.0 |
| TOTAL - ICE INFORMATION | 233.0 | 298.0 | 434.1 | 284.3 | 231.2 | 55.9 | 322.7 | 207.0 | 2066.2 |

(1) Rounded in thousands of dollars
(2) Estimated costs pending financial closeout

| ICE MANAGEMENT | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979(2) | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| **Corps of Engineers - Detroit District** | | | | | | | | | |
| (a) Island Transportation Investigations | $13.5 | $ - | $ - | $ - | $ - | $ - | $ 8.4 | $ - | $ 21.9 |
| (b) Sugar Island ferry dock bubbler-flusher systems | 9.9 | 7.9 | 1.5 | 2.7 | 5.9 | 12.0 | 3.8 | 10.0 | 53.7 |
| (c) Modification of Sugar Island ferry | - | 73.0 | - | 10.0 | - | - | - | - | 83.0 |
| (d) Lime Island Airboat | - | 6.0 | 9.4 | 6.7 | 3.6 | 11.7 | 12.6 | 8.0 | 58.0 |
| (e) Lime Island Air-Bubbler System | 64.6 | 59.8 | - | - | - | - | - | - | 124.0 |
| (f) Design of Bubbler System for Middle Neebish Channel | - | 2.0 | - | - | - | - | - | - | 2.0 |
| (g) St. Clair - Detroit River System Study | - | 80.2 | - | - | - | - | - | - | 80.2 |

TABLE IV (continued)

| ICE MANAGEMENT (continued) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979(²) | TOTAL |
| (h) Saginaw Bay thermal Ice Suppression Test design, construction, testing, and removal | - | 8.9 | 10.0 | 299.5 | 67.6 | - | - | 3.0 | 389.0 |
| (i) Model study of Little Rapids Cut | - | - | 24.8 | 202.3 | 61.7 | - | - | - | 288.8 |
| (j) St. Marys River navigation ice boom design, construction, testing | - | - | - | 40.0 | 628.8 | - | - | - | 66 |
| (k) St Marys River ice boom, modification, repairs, reinstallation and removal and redesign | - | - | - | - | - | 65.4 | 100.9 | 50.0 | 216.3 |
| (l) Advance Work - St Marys River ice boom | - | - | - | - | 47.8 | - | - | - | 47.8 |
| (m) Analysis and data collection Saginaw Bay thermal ice suppression | - | - | - | - | 12.0 | - | - | - | 12.0 |
| (n) Instrumentation of ice boom St. Marys River | - | - | - | - | 67.0 | - | - | - | 67.0 |
| (o) Shore erosion and structure damage | - | - | - | - | 45.0 | - | - | - | 45.0 |
| (p) Analytical study St Clair River physical hydraulic ice model | - | - | - | - | - | - | 10.0 | - | 10.0 |
| (q) St Clair River physical hydraulic ice model | - | - | - | - | - | - | 311.6 | 183.4 | 495.0 |
| (r) St Clair River model field data support | - | - | - | - | - | - | 22.8 | 22.0 | 44.8 |
| (s) St Lawrence River levels and flows | - | - | - | - | - | - | 8.6 | 25.0 | 33.6 |
| (t) Madeline Island airboat tests | - | - | - | - | - | - | 1.8 | - | 1.8 |
| (u) Winter Navigation Reporting Center operation | - | - | - | - | - | - | 10.0 | 10.0 | 20.0 |
| (v) Shore erosion dock damage | - | - | - | - | - | - | 15.4 | 50.0 | 65.4 |
| (w) Galop Island flow distrubution | - | - | - | - | - | - | - | 2.2 | 2.2 |
| **Corps of Engineers - St. Paul District** | | | | | | | | | |
| (a) Preparation of a report on FY-71 Duluth Harbor bubbler system | 5.0 | - | - | - | - | - | - | - | 5.0 |
| (b) Superior Harbor entrance bubbler system | - | 5.0 | - | - | - | - | - | - | 5.0 |
| (c) Howards Bay, Superior Harbor bubbler system | - | 55.0 | 60.0 | - | - | - | - | - | 115.0 |
| **Corps of Engineers - Buffalo District** | | | | | | | | | |
| Niagara River ice boom study | - | 12.0 | - | - | - | - | - | - | 1[illegible] |
| **U.S. Fish and Wildlife Service** | | | | | | | | | |
| Environmental data collection, Saginaw Bay thermal ice suppression test | - | 25.0 | 40.0 | 18.0 | 65.0 | - | - | - | 148.0 |
| Documentation mathmetical model | - | - | - | - | - | - | - | 3.0 | 3.0 |
| TOTAL - ICE MANAGEMENT | 93.0 | 334.8 | 145.7 | 579.2 | 1004.4 | 89.1 | 505.9 | 366.6 | 3118.7 |

**TABLE IV (continued)**

**ICE NAVIGATION**

| | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979[2] | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| **U.S. Coast Guard** | | | | | | | | | |
| (a) Water bubbler test on USCG RARITAN | $ 60.2 | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ 60.2 |
| (b) Follow-The-Wire navaid test, Muskegon Harbor | 2.2 | - | - | - | - | - | - | - | 2.2 |
| (c) Icebreaker support in Straits area | 38.0 | - | - | - | - | - | - | - | 38.0 |
| (d) Fixed and floating aids to navigation tests | 17.0 | 110.0 | 75.0 | 25.0 | - | - | - | - | 227.0 |
| (e) Laser range and radio transponder beacon (RACON) aids to navigation test | 2.6 | 33.2 | 15.0 | - | - | - | - | - | 50.8 |
| (f) Crew safety and survival tests | - | 125.0 | 240.0 | 35.0 | 25.0 | - | - | - | 425.0 |
| (g) Bubbler-wire guidance system studies and design for Whitefish Bay | - | 22.1 | - | - | - | - | - | - | 22.1 |
| (h) Water cannon non-conventional icebreaking tests | - | 23.7 | - | - | - | - | - | - | 23.7 |
| (i) Loran-C navigation system development | - | - | - | - | 183.0 | - | 170.0 | - | 353.0 |
| **Maritime Administration** | | | | | | | | | |
| (a) Precise Laser Radar Aid to Navigation System (PLANS PRANS) tests and development | 50.0 | 218.0 | 78.0 | 10.0 | - | - | - | - | 356.0 |
| (b) Sociological assessment questionnaire | - | - | - | 15.0 | - | - | - | | 15.0 |
| **St. Lawrence Seaway Development Corporation** | | | | | | | | | |
| Precise All-Weather Navigation System (PAWNS) development | - | - | - | 125.0 | 30.0 | - | 700.0 | | 855.0 |
| TOTAL - ICE NAVIGATION | 170.0 | 532.0 | 408.0 | 210.0 | 238.0 | | 870.0 | - | 2428.0 |

**ICE CONTROL**

| | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979[2] | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| **St. Lawrence Seaway Development Corporation** | | | | | | | | | |
| (a) Procure conceptual designs of ice control structures | $50.0 | - | - | - | - | - | - | - | $ 50.0 |
| (b) Ogdensburg-Prescott ice boom gate | - | 400.0 | 25.0 | - | - | - | - | - | 425.0 |
| (c) System Plan for All-Year Navigation (SPAN) Study | - | 200.0 | 25.0 | - | - | - | - | - | 225.0 |

**TABLE IV (continued)**

| ICE CONTROL (continued) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979(2) | TOTAL |
| (d) Copeland Cut test ice boom | - | - | - | 280.0 | - | - | - | - | 280.0 |
| (e) Copeland Cut and Ogdensburg-Prescott ice boom model studies | - | - | - | - | 575.0 | - | - | - | 575.0 |
| (f) Galop Island ice boom modification | - | - | - | - | - | 124.0 | 176.0 | - | 300.0 |
| **Corps of Engineers - Buffalo District** | | | | | | | | | |
| St. Lawrence River activities management | - | - | 22.5 | - | - | - | - | - | 22.5 |
| TOTAL - ICE CONTROL | $50.0 | 600.0 | 72.5 | 280.0 | 575.0 | 124.0 | 176.0 | - | $1877.5 |

| ICE ENGINEERING | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979(2) | TOTAL |
| **Corps of Engineers - Cold Regions Research and Engineering Laboratory (CRREL)** | | | | | | | | | |
| (a) Studies and measurements of ice forces on structures - St. Lawrence River | $37.0 | $ 55.0 | $ 65.0 | $40.0 | - | - | - | - | $197.0 |
| (b) Preliminary design of Ice Engineering Modeling Facility | 10.0 | 50.0 | - | - | - | - | - | - | 60.0 |
| (c) Studies and measurements of ice forces on piles | 6.5 | 30.0 | 60.0 | - | - | - | - | - | 96.5 |
| (d) Field measurements at Lime Island air bubbler | 6.5 | - | - | - | - | - | - | - | 6.5 |
| (e) Air bubbler systems effectiveness studies | - | 20.0 | - | - | - | - | - | - | 20.0 |
| (f) Instrumenting a light structure at Toledo Harbor, Ohio | - | 10.0 | - | - | - | - | | - | 10.0 |
| (g) St. Marys River ice boom monitoring | - | - | - | - | - | - | 28.0 | 30.0 | 58.0 |
| (h) St. Marys River "Early Warning" system | - | - | - | - | - | - | 9.0 | - | 9.0 |
| (i) St. Marys River vibration study | - | - | - | - | - | - | 30.0 | 20.0 | 50.0 |
| (j) Floating ice barrier effectiveness study | - | - | - | - | - | - | - | 50.0 | 50.0 |
| (k) Ice forces on marine structures | - | - | - | - | - | - | - | 100.0 | 100.0 |
| **St. Lawrence Seaway Development Corporation** | | | | | | | | | |
| Determination of forces on ice boom structure | - | 1.4 | - | - | - | - | - | - | 1.4 |
| **U.S. Coast Guard** | | | | | | | | | |
| Assist CRREL in measurement of ice forces on structures | - | 10.0 | - | - | - | | - | - | 10.0 |
| TOTAL - ICE ENGINEERING | 60.0 | 176.4 | 125.0 | 40.0 | - | - | 67.0 | 200.0 | 668.4 |

**TABLE IV (continued)**

| ECONOMIC EVALUATION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979(1) | TOTAL |
| Economic Evaluation of Work Group activities and preparation of origin-destination traffic matrices | | | | | | | | | |
| Corps-Detroit District and North Central Division | $2.7 | $12.4 | $10.0 | $6.6 | $1.6 | $ - | $7.1 | $12.5 | $ 52.9 |
| U.S. Coast Guard | - | - | 1.0 | - | - | - | - | - | 1.0 |
| St. Lawrence Seaway Development Corporation | - | 3.0 | 2.0 | - | - | - | - | - | 5.0 |
| Bureau of Economic Analysis | - | - | 85.0 | - | - | - | - | - | 85.0 |
| TOTAL - ECONOMIC EVALUATION | 2.7 | 15.4 | 98.0 | 6.6 | 1.6 | - | 7.1 | 12.5 | 143.9 |

| PUBLIC INFORMATION SUBCOMMITTEE | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979(1) | TOTAL |
| Preparation and issuance of public information brochures and news releases and support and coordination of public information activities | | | | | | | | | |
| Corps of Engineers - Detroit District | $ - | $40.8 | $4.5 | $ .7 | $1.3 | $ - | $15.8 | $10.0 | $73.1 |
| Great Lakes Environmental Research Labortory | - | 1.0 | 1.0 | - | - | - | - | - | 2.0 |
| U.S. Coast Guard | - | .4 | 1.0 | .3 | - | - | - | 1.0 | 2.7 |
| St. Lawrence Seaway Development Corporation | - | 1.0 | .4 | 1.0 | - | - | 1.0 | 1.0 | 4.4 |
| Maritime Administration | - | 1.0 | - | 1.0 | - | - | 1.0 | | 3.0 |
| Environmental Protection Agency | - | - | - | 1.0 | - | - | 1.0 | 1.0 | 3.0 |
| Cold Regions Research and Engineering Laboratory | - | 1.0 | 1.0 | 1.0 | - | - | 1.0 | 1.0 | 5.0 |
| TOTAL - PUBLIC INFORMATION | - | 45.2 | 7.9 | 5.0 | 1.3 | - | 19.8 | 14.0 | 93.2 |

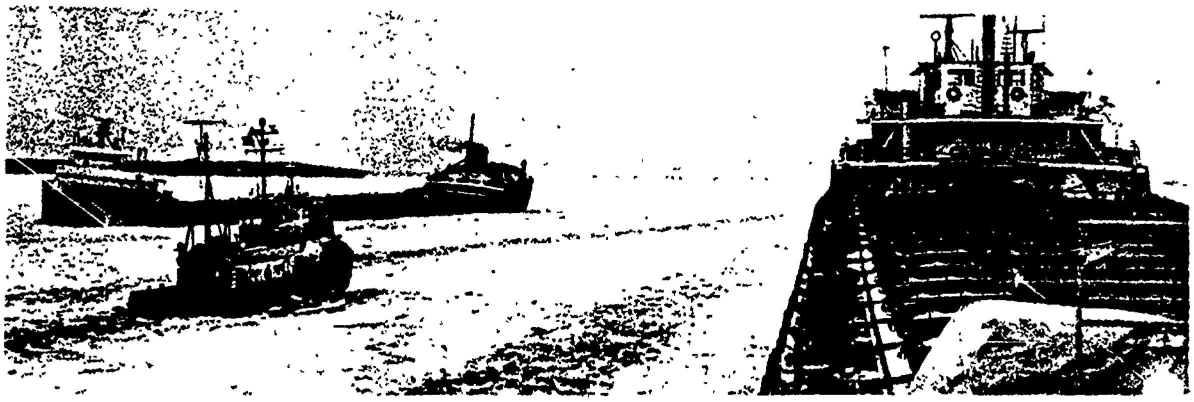
**TABLE IV (continued)**

| ENVIRONMENTAL EVALUATION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979(3) | TOTAL |
| Coordination and Review of Environmental Data Collection, EIS's and Evaluation of Individual Work Group Activities: | | | | | | | | | |
| Environmental Protection Agency | $ 4.0 | $13.5 | $ 18.6 | $ 20.0 | $ 24.0 | $ 5.0 | $ 26.0 | $ 26.0 | $ 137.1 |
| U.S. Fish and Wildlife Service | 10.0 | 41.0 | 26.0 | 26.0 | 35.0 | - | 28.6 | 26.0 | 192.6 |
| Bureau of Outdoor Recreation | 8.0 | 20.0 | 14.0 | 14.0 | 23.0 | 4.7 | - | - | 83.7 |
| U.S. Coast Guard | - | .3 | 4.0 | .3 | 19.0 | - | 4.6 | 9.0 | 37.2 |
| Great Lakes Environmental Research Laboratory | 2.0 | 5.0 | 4.0 | 4.0 | 4.4 | - | 5.0 | 4.0 | 28.4 |
| Corps of Engineers- Detroit District | - | 7.0 | 14.1 | 12.1 | 18.6 | 3.1 | 43.8 | 13.5 | 112.2 |
| St. Lawrence Seaway Development Corp. | - | - | - | - | - | - | 20.0 | 16.5 | 36.5 |
| Maritime Administration | - | - | - | - | - | - | 1.0 | - | 1.0 |
| **U.S. Fish and Wildlife Service** | | | | | | | | | |
| (a) Fish Study and Turbulence Effects on Shallow Water Sediment and Organisms | - | - | - | 42.0 | - | - | - | - | 42.0 |
| (b) Coordinate Demonstration Activities and relate to total system investigated by the Survey Study | - | - | - | - | 17.5 | - | - | - | 17.5 |
| (c) Study of distribution and abundance of macrobenthos, lower St. Clair River | - | - | - | - | - | - | 21.0 | - | 21.0 |
| **St. Lawrence River Environmental Study** | | | | | | | | | |
| U.S. Fish and Wildlife Service | - | - | - | - | - | 70.0 | 225.0 | - | 295.0 |
| St. Lawrence Seaway Development Corp | - | - | - | - | 199.0 | - | - | - | 199.0 |
| Bureau of Outdoor Recreation | - | - | - | - | 16.0 | - | - | - | 16.0 |
| **Corps of Engineers - St. Paul District** | | | | | | | | | |
| Bubbler system, Duluth-Superior Harbor | - | 8.0 | 30.0 | - | - | - | - | - | 38.0 |
| **Great Lakes Basin Commission** | | | | | | | | | |
| (a) Environmental studies coordinator and Environmental Monitoring Plan refinement | - | - | - | - | - | - | - | 30.0 | 30.0 |
| (b) Evaluation of benthic dislocation due to an induced wave in an ice environment | - | - | - | - | - | - | - | 10.0 | 10.0 |
| (c) Effects of winter navigation on waterfowl and raptorial birds, St Marys River | - | - | - | - | - | - | - | 20.0 | 20.0 |

**TABLE IV (continued)**

| ENVIRONMENTAL EVALUATION | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979(³) | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| (d) Effects of ship induced waves in an ice environment on the St. Marys River ecosystem | - | - | - | - | - | - | - | 58.0 | 58.0 |
| (e) Ship induced waves - ice and physical measurements on the St. Marys River | - | - | - | - | - | - | - | 22.0 | 22.0 |
| (f) Fisheries study | - | - | - | - | - | - | - | 60.0 | 60.0 |
| (g) Analysis of control sites (Paired Sites) glaciological and limnological portion | - | - | - | - | | - | - | 85.0 | 85.0 |
| (h) Comparative study - St. Marys and St. Lawrence Rivers | - | - | - | - | - | - | - | 23.1 | 23.1 |
| (i) Waterfowl, waterbirds, and raptors, St. Lawrence River | - | - | - | - | - | - | - | 44.3 | 44.3 |
| TOTAL - ENVIRONMENTAL EVALUATION | 24.0 | 94.8 | 110.7 | 118.4 | 356.5 | 82.8 | 375.0 | 447.4 | 1609.6 |

| PROGRAM MANAGEMENT | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979(³) | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| **Corps - Detroit District and North Central Division** | | | | | | | | | |
| Travel, reproduction, report preparation, payroll, organization, scheduling, planning and design costs for overall management of Demonstration Program | $111.3 | $ 181.4 | $ 192.5 | $ 216.3 | $ 343.2 | $ - | $ 140.0 | $ 260.0 | $ 1,444.7 |
| **St. Lawrence Seaway Development Corporation** | | | | | | | | | |
| Technical Review Panel review of Demonstration Program activities | - | - | - | 30.0 | - | - | - | - | 30.0 |
| TOTAL - PROGRAM MANAGEMENT | 111.3 | 181.4 | 192.5 | 246.3 | 343.2 | - | 140.0 | 260.0 | 1,474.7 |
| Reallocation to survey study | - | - | - | - | - | - | - | - | 187.8 |
| TOTAL - Allocated or expended Demonstration Program funds | 744.0 | 2,374.0 | 1,547.5 | 1,828.4 | 2,645.1 | 361.0 | 2,300.0 | 1,868.0 | 13,668.0 |
| TOTAL - Accumulated Funds Allotted | 744.0 | 3,118.0 | 4,665.5 | 6,493.9 | 9,139.0 | 9,500.0 | 11,800.0 | 13,668.0 | |
| TOTAL - Accumulated Expenditures | 744.0 | 3,022.0 | 4,616.4 | 6,386.2 | 9,137.4 | 9,489.2 | 11,472.7 | 13,668.0 | |



*Coast Guard Cutter at work.*

*General cargo study*

In April of 1974 the Bureau of Economic Analysis completed for the Winter Navigation Board a study entitled: "Extending the Great Lakes-St. Lawrence Seaway Shipping Season: The Economic Effects on General Cargo and Related Industries." The purpose of this study was to evaluate the economic impact of general cargo movements and the further direct, indirect, and induced economic effects on an eleven state study area, as a consequence of extending the shipping season on the Great Lakes-St. Lawrence Seaway The eleven state region consisted of Ohio, Michigan, Indiana, Illinois, Wisconsin, Minnesota, Iowa, Nebraska, South Dakota, North Dakota, and Wyoming.

The evaluation was based on (1) primary-impact, transport-sensitivity model, (2) a secondary economic impact model, and (3) preliminary aggregate estimates of the total economic impact on the study area as a whole Further refinement of the models which was planned for a second phase of the study was not conducted. The approach used avoids the confusion of benefits due to other public and private investments which would have occurred without season extension, with those due solely to season extension.

The study indicated the study area as a whole has been growing at a rate somewhat slower than the Nation in recent history and the season extension program, with respect to general cargo movements, would offset part of this relative decline, particularly in the manufacturing states in the study area. Information aquired during the study was used in preparation of the survey study

*Work group cost data*

The cost data compiled from each work group consisted of the material, installation, operation, and maintenance costs associated with a given work activity. In addition, data on the effectiveness of various activities were obtained The cost and effectiveness data, which were collected during the Demonstration Program have been evaluated and will be utilized to insure that the most cost-effective measures tested during the Demonstration Program will be selected for use in any plans of improvement to extend the navigation season. The total costs of specific FY 72-FY 79 Demonstration Program activities, by work group and by expenditures, chargeable to various items are depicted in Table IV The FY 79 funds are estimated costs pending financial closeout.

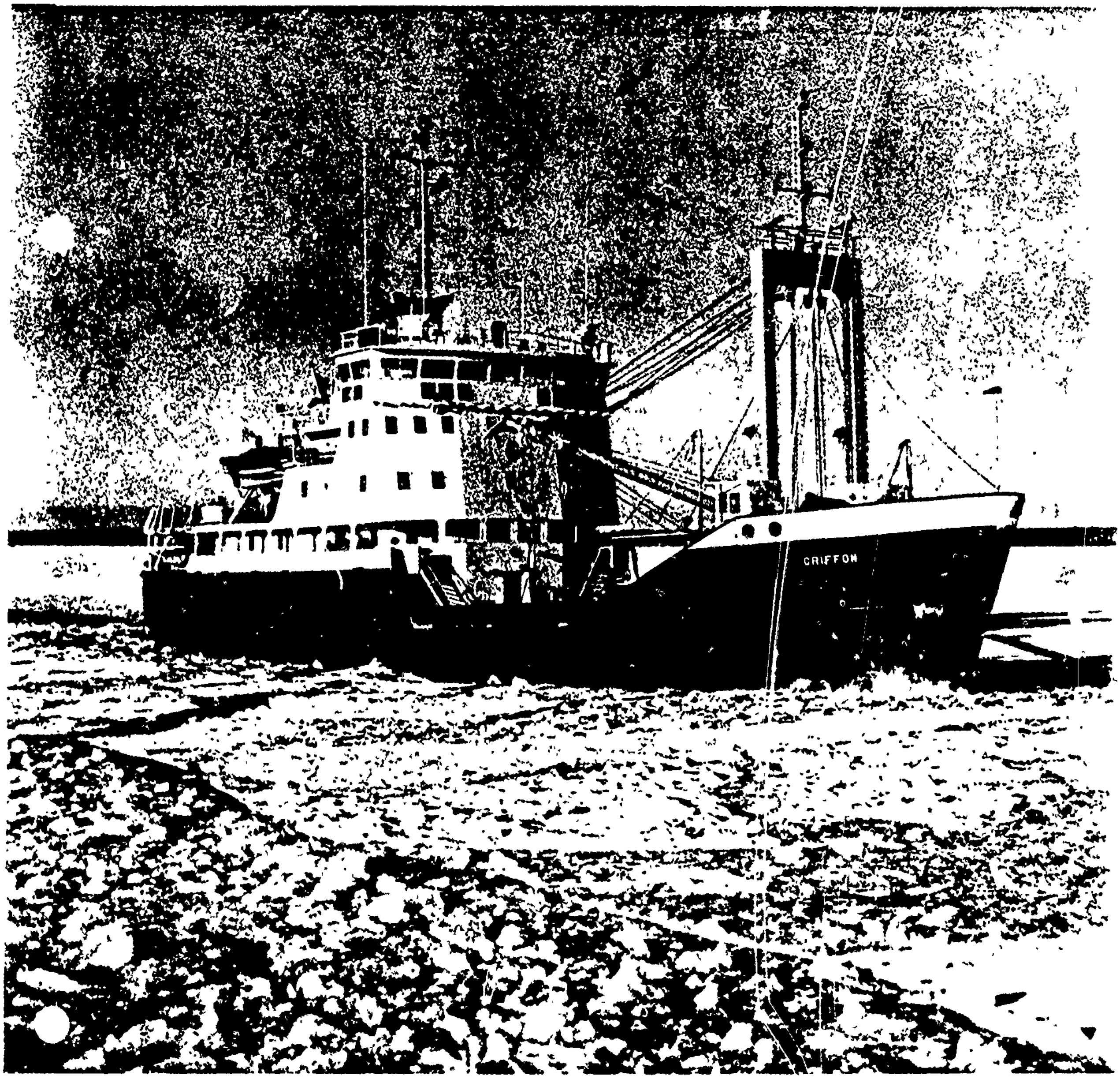
**Canadian co-participation**

The Canadian Government has not, as of this writing, issued a formal statement regarding their position concerning an extended navigation season. There has been, however, informal cooperation between various agencies of both governments in an effort to keep the Canadian Government informed about an issue of concern to both neighboring countries.

*Winter Navigation Board and Working Committee*

In an observer status, Canadian representation throughout the Demonstration Program has been present on both the Winter Navigation Board and the Working Committee. The St. Lawrence Seaway Development Corporation has worked closely with its operational Canadian counterpart, The St Lawrence Seaway Authority, and the Canadian Marine Transportation Administration.

*The Canadian* Griffon *breaks ice in the St. Marys River.*




*Winter navigation from Montreal to the Atlantic Ocean*

There is currently navigation year-round from the Atlantic Ocean as far as Montreal on the St. Lawrence River. In addition to conventional icebreakers the Canadians have used on an operational basis a self-propelled air cushion vehicle, both for icebreaking and flood control purposes.

*Canadian Coast Guard air cushion vehicle, Voyageur, in action.*

The Canadian Marine Transportation Administration, Ministry of Transport, has prepared Annual Reports on data collection on the Great Lakes-St. Lawrence Seaway System. Included in these reports are studies on ice coverage and conditions as observed both from their icebreaking research vessels and from aerial fly-overs. In addition, the Canadians documented ice thickness, shore observations, hydrometeorological data, icebreaking operations and operational problems as they occurred. The data collected are intended to be compared with past and possibly future studies pertaining to an extension of the navigation season.

*Bow mounted air cushion vehicle,* Iceater, *tests*

*Joint U.S.-Canadian Icebreaking Guide*

The U.S. and Canadian Coast Guards cooperated in the publication of a *Joint U.S. Coast Guard-Canadian Coast Guard Guide to Great Lakes Ice Navigation* to coordinate the standardized ice navigation activities. The guide summarizes information available to shippers with regard to communication and reporting procedures for ships leaving ports, up-to-date ice chart broadcasts, weather forecasts and winter navigation data transmitted periodically by the Ice Navigation Center. Advice and requirements for ships operating in ice both independently and with icebreaker support is supplied in the publication as well. The guide also provides a summary of anticipated ice conditions through the Great Lakes.

*Seaway Corporation/Seaway Authority coordination*

The two Seaway entities, the St. Lawrence Seaway Development Corporation of the United States and the St. Lawrence Seaway Authority of Canada are authorized by their respective enabling legislation to coordinate their activities directly. Season extension coordination between the entities has proceeded under this same authority. One example of coordination includes the frequent meetings between the entities each year to reach agreement on navigation season closings and openings. In addition, a joint SLSDC/SLSA task group on navigation season extension coordinates study efforts and data exchange and proposes joint, in-house programs for incremental extensions. Finally, Seaway Authority representatives have participated as observers on the Ice Control Work Group (chaired by SLSDC) and the Ad Hoc Committee on St. Lawrence River Demonstration Activities (chaired by NOAA-GLERL).

## Public involvement

*St. Marys River Operational Plan*

Near the end of each year at Sault Ste. Marie, Michigan, participating agencies, organizations, governments and businesses with a common interest in the St. Marys River Demonstration Program meet to look ahead at the coming year. The purpose of the meeting is to develop a plan which will allow the St. Marys River system to function as normally as possible and at the same time to allow commercial navigation to continue as long as possible into the winter season.

Primary elements in the planning involve provisions for the transportation of inhabitants for the four major islands in the area and for icebreaking activity. Also included in the procedure are steps for the halting of ship traffic in the system should island transportation be jeopardized. At the conclusion of the annual meeting, a press conference is held to provide concerned local residents with information relating to the coming year. In FY 78 the meeting was followed by a public meeting to permit area residents to discuss their views.

*Public meetings and workshops*

Public involvement in the planning process is a vital key to public acceptance and to the eventual implementation of a plan. Public meetings and public workshops are two methods of achieving effective involvement.

Public meetings were established to inform the public about studies and proposals relating to the winter navigation program and to provide an informal arena for the exchange of views and pertinent information. The workshops, on the other hand, functioned in a small, less structured format in which mixed interested groups discussed issues and recommended problem solutions.

On 17 February 1973 a public meeting was held at St. Ignace, Michigan. As the result of a Congressional inquiry the Detroit District Engineer attended as a representative of the Winter Navigation Board. The meeting was scheduled with residents of Drummond Island, Chippewa County officials, the U.S. Coast Guard, and the U.S. Army Corps of Engineers to hear complaints from area residents on Drummond Island concerning interruption of ferry service allegedly resulting from the extended navigation season. The meeting resulted in a study of conditions at Drummond Island which concluded that Winter Navigation had no effect on Drummond Island ferry operations.

A public workshop was held in July 1975 at Sault Ste. Marie, Michigan, to obtain public views, ideas and concerns regarding the effects and problems relating to the safe management of shorelines affected by winter vessel transits. The workshop also included the presentation of the results of a study conducted in 1974 on the effects of winter navigation to this shoreline.

A public meeting was also held January 1977 at the Soo to obtain public needs and viewpoints relative to the navigation season extension survey and the Demonstration Program. Concepts dealing with the

future directions of both the Survey and the Demonstration Program were presented to the public in Cleveland in October 1977.

On 1 August 1978 a public meeting was held in Alexandria Bay, New York. The purpose of the meeting was to inform the residents of the St. Lawrence River of the preparations the Winter Navigation Board proposed for the demonstration on the St. Lawrence River for the winter of 1978-79 and to answer their questions relating to those plans.

*Winter Navigation Board and Working Committee meetings*

Throughout the eight years of the program 32 Board meetings and 42 Working Committee meetings have been held at various locations on the Great Lakes-St. Lawrence Seaway system. At these meetings the various involved agencies discuss the progress and goals of Winter Navigation activities. The meetings are open to the public and members of the public are allowed to provide formal statements on their views.

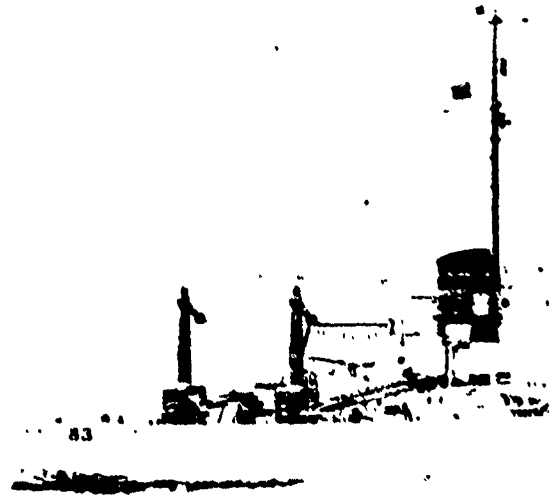
*Public opinion*

The Demonstration Program and Survey Study are separate and distinct. Each has a separate function as described in the authorizing legislation

Potential impacts which may result from an extended navigation season have made season extension on the Great Lakes and St. Lawrence Seaway System a controversial issue Public involvement activities have served to highlight these concerns.

Governmental, organizational, and individual environmental concerns have raised objections to the extension of the season. Opposition has also been voiced by others, including the State of New York, the New York Department of Environmental Conservation (NYDEC), hydroelectric power entities (Power Authority of the State of New York, Soo Edison), sport groups, and tourism concerns. Riparians, affected island residents, freight railroads, and coastal zone management agencies have raised issues of concern Certain Congressmen and some trade unions as well as some private citizens are opposed to the extension of the navigation season.

*Coast Guard Cutter at work.*



Those who are in favor of the season extension of the System include industrial interests, including those of steel, grain, power, coal, petroleum and mining, domestic and foreign shippers (import and export) and ship owners and operators The St. Lawrence Seaway Authority and several Port Authorities support the program. Proponents also include some Congressmen and trade unions and some private citizens. The State of Michigan has issued a statement supporting a modest, yet flexible, extension on the upper four Great Lakes, provided a number of environmental, economic, and operational conditions are met.

Others have expressed concern, but remain uncommitted at this writing. The States of Wisconsin, Minnesota, Illinois, Indiana, Ohio, Pennsylvania, and the Government of Canada have not issued formal statements regarding their position.

The controversy with navigation season extension is based on a number of issues.

Agencies with environmental expertise and responsibilities and environmentalists point out potential damage to natural resources (fisheries, wildlife, etc.), and possible adverse effects of dredging. The results of an environmental assessment (NYDEC) indicated irreversible adverse effects to the environment due to the Demonstration Program.

Potential shore erosion and shore structure damage are a major issue of contention. The threat of oil and hazardous substance spills, possible changes to levels and flows in the system, and cross-channel transportation (island-mainland), are also issues. Private industry and governmental agencies have questioned whether water intakes and sewer outflows will be affected by projected water levels in the program.

Tourism, railroad concerns, and riparians have raised brought up the matter of potential economic losses of season extension. Social problems involve port personnel (schedules, safe working conditions) and recreation (ice fishing, snowmobiling, etc.). Power entities question the liability regarding flooding, and the potential problems of winter navigation though ice booms, which are installed to provide a stable ice cover above generating plants.

*Winter Navigation Seminar*

In December 1973, the Department of the Army sponsored a Great Lakes and St. Lawrence Seaway navigation seminar at Detroit. The purpose of the seminar was to furnish the public with further information regarding the winter navigation program and to provide a forum for the expression of views and discussion by all parties with an interest in the program.

*Public Information Brochures*

Another effective means of public involvement is the use of concise information publications. During the first two years of the program, two fact sheets were produced, stating the purpose of the program and plans for program activities. In May 1978, the publication, *Winter Navigator* was put out by the Public Involvement Sub-Committee.


CONNECTICUT

*Great Lakes tug assists carrier.*

# PART IV: FINDINGS AND CONCLUSIONS

*Findings: The overall finding during the eight years of the Demonstration Program is that the traditional navigation season on the Great Lakes-St. Lawrence Seaway System has been successfully extended.*

Commercial navigation has successfully been extended beyond the historic closing date of 16 December on the upper four Great Lakes and connecting channels during every year of the program. Year-round shipping was achieved during the latter five years. On the St. Lawrence River, where historically the season extended from mid-April to early December, the longest commercial season in history was recorded in 1975 with a 25 March opening and a 20 December closing.

As discussed in the following paragraphs, specific findings resulted from Demonstration Program activities in the areas of ship movement through ice, navigation aids, ice and weather information, crew safety and survival, ice control, and island transportation. In addition, under an ongoing program, year-round lock operation was demonstrated.

*1. Movement of vessels through winter ice conditions was demonstrated.*

The use of preventative icebreaking and the use of ship convoys were useful tools in moving vessels through ice. The use of air bubbler systems and a thermal ice suppression system were both effective in melting or reducing ice cover and easing vessel movement through areas of stable ice cover. The air bubbler systems also allowed vessels to maneuver in confined areas of the Duluth-Superior Harbor. The bubbler system at the Lime Island Turn in the St. Marys River showed the practicability of this type of system in reducing ice thicknesses in a river and demonstrated its use in aiding the turning of the long lake vessels.

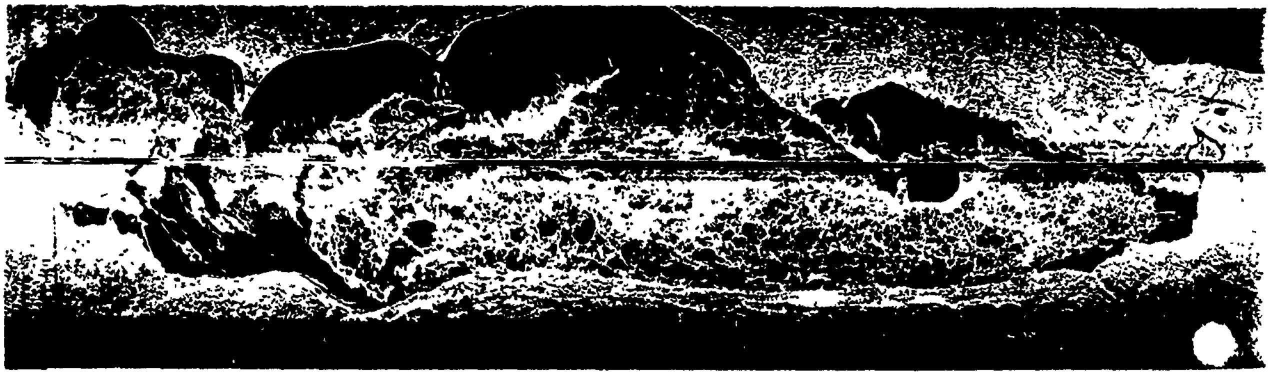
*2. Navigation aids suitable for use in varying ice and weather conditions were only partially successful.*

Specially designed ice buoys for use under ice conditions showed some success, but due to their limited utility, emphasis was placed on developing various electronic navigation systems. A mini-Loran C navigation system was used on the St. Marys River, but its accuracy within narrow channels has not yet been demonstrated. A Precise All Weather Navigation System (PAWNS) was not fully demonstrated during the program. Radar transponder beacons (RACONS) successfully extended the range and utility of shipboard radar units.

*3. Weather and ice information are required by vessel operators for safe transit through the system.*

Weather and ice information was disseminated by a special Ice Navigation Center at the Ninth Coast Guard District Headquarters in Cleveland, Ohio in coordination with the National Weather Service. Aerial reconnaissance and Side-Looking Airborne Radar (SLAR), were sucessfully used as inputs to the ice information portion of the program. The aerial

*SLAR image of Lake Erie.*



reconnaissance and SLAR provided real-time information on the extent of ice cover. Methods of providing both long and short range ice forecasts for all areas of the Great Lakes were developed by the National Oceanic and Atmospheric Administration. Ice forecast services are furnished by National Weather Service Forecast offices in Ann Arbor, Michigan, and Buffalo, New York. A model was developed to predict the ice breakup period in the St. Lawrence River. The ice breakup forecast technique is used to allow advance scheduling of ocean trade vessels into the system.

*4. Crew safety and survival can be aided by tested and approved survival equipment.*

Crew safety and survival in an extended season were given considerable attention. The Coast Guard field tested and evaluated a variety of personnel exposure suits and survival equipment. Several types of exposure suits have been approved for use by shippers by the Coast Guard. Emergency Position Indicating Radio Beacons (EPIRBs) and hand held radar transponders have shown effectiveness in pinpointing the location of both ships and personnel, enhancing the efficiency of search and rescue operations.

*5. Ice control structures can be designed to permit navigation through them while maintaining a stable ice cover and minimizing ice jams.*

Ice jams in constricted portions of the system, especially the St. Marys, St. Lawrence, and St. Clair Rivers, can prevent the passage of all but a few vessels with substantial ice operating capabilities. The jams also cause flooding problems and in some cases reduce the flow of water to power plants and municipal intakes. The annual installation of a navigation ice boom and other structures at the head of Little Rapids Cut in the St. Marys River allowed vessel movement to continue year-round during four of the last five years of the program with no major ice problems occurring. Similar, but limited, demonstrations were conducted at Copeland Cut in the St. Lawrence River with the same results. Model studies were conducted in FY 79 to determine the type and effectiveness of ice control structures needed at the head of the St. Clair River.

*6. Operations at the locks at Sault Ste Marie, Michigan, demonstrated that year round lock operations are possible.*

Under ongoing investigations, systems for winterizing lock operating machinery were successfully demonstrated. The use of co-polymer coatings and steamlines were effective in removing ice from lock walls. A bubbler system and air curtain were effective in keeping floating ice out of gate recesses and limiting the amount of ice entering locks. Protective housing and the use of heated cables helped prevent ice buildup on lock gate machinery.

*7. Extended season navigation has the potential to contribute to shore erosion problems and increased damage to docks.*

Studies conducted during the program have indicated that winter navigation has the potential to contribute to increased shore erosion and damage to docks in limited areas of the connecting channels including the St. Marys, St. Clair and St. Lawrence Rivers. Further investigation is required to distinguish between that damage occuring below the ordinary high water mark which is caused by ship movement in ice and that caused by natural ice movement.

*8. Transportation for island residents can be maintained while permitting navigation through the area.*

To test means of improving the ice operating capabilities of the Sugar Island ferry, several modifications were made to its hull and power com-

ponents. These modifications enabled the ferry to operate in moving ice floes. The installation of the St. Marys River ice boom above Little Rapids Cut reduced the amount of ice moving down the Cut, further increasing the ferry's capabilities. Additionally, the installation of an air bubbler-flusher unit at the Sugar Island ferry mainland dock, to create a surface current to physically flush ice away from the dock, enabled the ferry to land more easily. An airboat was utilized at Lime Island to provide transportation for the residents of that Island. During the program, several improvements were made to the airboat but the residents have expressed dissatisfaction with this form of transportation.

*9. Unresolved questions precluded actual demonstration of extended commercial navigation on the St. Lawrence River.*

The upper four Great Lakes and their connecting channels are significantly different, both physically and administratively, from the lower portion of the system.

On the upper four Great Lakes, the program was carried out essentially in the United States waters and did not require co-participating involvement of Canada. In the St. Lawrence Seaway, activities were in the waters of both Canada and the United States and could not be implemented to the same extent, that is including full vessel tests and similar winter operations, without substantial improvements in the all-Canadian portion of the St. Lawrence River. In addition, opposition by power entities initially delayed Demonstration Program execution on the St. Lawrence Seaway portion of the system.

The Board under these circumstances stressed operation on the upper four Great Lakes in order to obtain prototype information and delayed such tests in the St. Lawrence River towards the end of the program in the belief that sufficient technical data would be acquired in the course of the program to allow resolution of the questions raised by local interests and New York State. Strong opposition by local interests, including the State of New York, finally precluded full Demonstration Program execution on the St. Lawrence Seaway portion of the system.

In their 1976 report the Board requested that in view of these circumstances on the St. Lawrence Seaway, Congress provide two additional years and appropriate funding to carry out the St. Lawrence Program including vessel tests. This funding and authority were provided, but the issues could not be resolved and comprehensive vessel tests were never carried out.

*10. Sufficient data on the effects of extended season navigation on the Great Lakes environment are not currently available.*

A limited number of environmental studies have been conducted on some of the demonstration program activities. While this does not comprise a complete analysis, adverse impacts to the environment have not been documented in the areas that have been investigated. Several baseline studies have been accomplished but they are not sufficient to make judgments as to the long range effects of the program. The New York Department of Environmental Conservation has completed a study for the Winter Navigation Board indicating irreversible adverse effects to the environment would occur and partially base their objection to the program on that study.

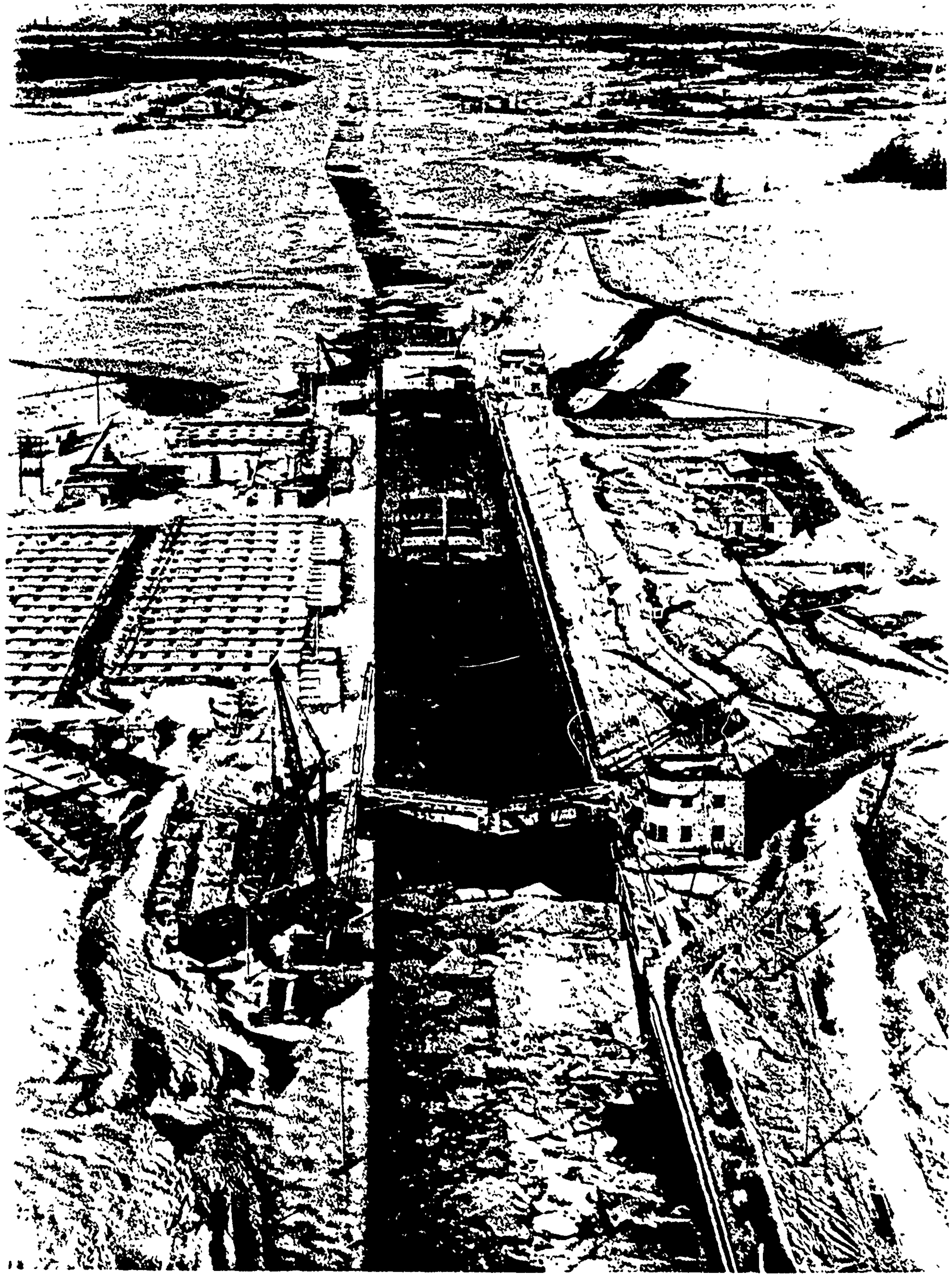
*Conclusions: The overall conclusion is that the practicability of navigation season extension on the upper four lakes of the Great Lakes-St. Lawrence Seaway system has been successfully demonstrated.*

The eight years of the demonstration program have shown that technically an extension of the traditional navigation season is practicable. Several issues still need to be resolved before a permanent season extension could be implemented.

1. Before the practicability of winter navigation in the St. Lawrence River can be determined, it must be demonstrated that certain existing ice control structures and related ice fields can be safely transited without disrupting the integrity of the ice fields and adversely affecting regulated water levels and flows of the river.

2. Significant amounts of environmental baseline data need to be collected to establish parameters against which to evaluate the extended season activities and to form part of the basis for measures and practices that may be necessary to protect the natural resources of the system.

3 The United States Government needs to seek appropriate Canadian participation in future extended season activities. Their participation is essential before overseas commercial shipping in the system can be extended.



*Aerial shows winter operation at U.S. Seaway lock.*

# V. THE FUTURE

The concept of a Demonstration Program, as envisioned by the Congress in the authorizing legislation, has provided a unique and invaluable opportunity for determining the problems, identifying the issues and testing site specific solutions for extended season navigation on the Great Lakes and St. Lawrence Seaway navigation system. In final perspective, the Program has significantly increased the understanding of the winter environment and its complexity and has measurably advanced the state-of-the-art of ice navigation.

The Program has also had as an objective the need to provide to Congress, and to bring to all interests, a timely and meaningful overview of the possibility of safe and practical year-round navigation on the Fourth Seacoast of the United States. In this objective it has provided the opportunity for industry, labor and interested society in general to examine, to investigate and to evaluate the issues and potential benefits and costs of winter navigation. This in itself, while fostering questions and controversy, has been a continuing measure of the importance and value of the enabling legislation.

This Demonstration Program Final Report does not contain recommendations concerning implementation of a navigation season extension. However the results and conclusions obtained over the span of eight years covered by the program are being used for formulating future plans, programs and recommendations to Congress under the survey study authority of Section 107(a), Public Law 91-611, of the 1970 River and Harbor Act.

Section 107(a) provides for a survey study to determine the feasibility of means of extending the navigation season on the Great Lakes and St. Lawrence Seaway System and to determine the extent of Federal interest, if any, in an extended navigation season. The Final Report for the survey study is currently being prepared by the U.S. Army Corps of Engineers and is scheduled to be released to the public on 31 December 1979 upon issuance of the Division Engineer, North Central Division, notice. The Final Report would then be forwarded to the Chief of Engineers office for Washington level review and coordination prior to submittal of the report to the Congress.

# Authority

**1970 River and Harbor Act (PL 91-611, December 31, 1970).**

*SECTION 107. River and Harbor Act of 1970*

*(a) The Secretary of the Army, acting through the Chief of Engineers, is authorized to conduct a survey of the Great Lakes and St. Lawrence Seaway to determine the feasibility of means of extending the navigation season in accordance with the recommendations of the Chief of Engineers in his report entitled "Great Lakes and St. Lawrence Seaway--Navigation Season Extension".*

*(b) The Secretary of the Army, acting through the Chief of Engineers, in cooperation with the Departments of Transportation, Interior, and Commerce, including specifically the Coast Guard, the St. Lawrence Seaway Development Corporation, and the Maritime Administration; the Environmental Protection Agency; other interested Federal agencies, and Non-Federal public and private interests, is authorized and directed to undertake a program to demonstrate the practicability of extending the navigation season on the Great Lakes and St. Lawrence Seaway. Such a program shall include, but not be limited to, ship voyages extending beyond the normal navigation season; observation and surveillance of ice conditions and ice forces; environmental and ecological investigations, collection of technical data related to improved vessel design; ice control facilities, and aids to navigation; physical model studies; and coordination of the collection and dissemination of information to shippers on weather and ice conditions. The Secretary of the Army, acting through the Chief of Engineers, shall submit a report describing the results of the program to the Congress not later than July 30, 1974. There is authorized to be appropriated to the Secretary of the Army not to exceed $6,500,000 to carry out this subsection.*

*(c) The Secretary of Commerce, acting through the Maritime Administration, in consultation with other interested Federal agencies, representatives of the merchant marine, insurance companies, industry, and other interested organizations, shall conduct a study of ways and means to provide reasonable insurance rates for shippers and vessels engaged in waterborne commerce on the Great Lakes and the St. Lawrence Seaway beyond the present navigation season, and shall submit a report, together with any legislative recommendations, to Congress by June 30, 1971."*

**Water Resources Development Act of 1974 (PL 93-251, March 7, 1974).**

*Sec 70. Section 107(b) of the River and Harbor Act of 1970 (84 Stat. 1818, 1820) is hereby amended by deleting "July 30, 1974" and inserting in lieu thereof "December 31, 1976", and deleting "$6,500,000" and inserting in lieu thereof "$9,500,000 "*

**Water Resources Development Act of 1976 (PL 94-587, October 22, 1976).**

*Sec 107. Section 107(b) of the River and Harbor Act of 1970 (84 Stat. 1818, 1820), as amended, is further amended by striking out "December 31, 1976" and inserting in lieu thereof "September 30, 1979" and striking out "$9,500,000" and inserting in lieu thereof "$15,968,000". Such section 107(b) is further amended in the second sentence thereof by striking out "environmental and ecological investigation;" and inserting in lieu thereof "environmental and ecological investigations, including an investigation of measures necessary to ameliorate any adverse impacts upon local communities.".*

# MEMORANDUM OF UNDERSTANDING

**Great Lakes and Saint Lawrence Seaway Navigation Season Extension Demonstration Program**

**Between**

**U.S. Army Corps of Engineers**
**Maritime Administration**
**U.S. Coast Guard**
**St. Lawrence Seaway Development Corporation**
**National Oceanic & Atmospheric Administration**
**Environmental Protection Agency**
**Department of the Interior**
**Federal Power Commission**

1. This Memorandum of Understanding prescribes the organization and procedures for managing, coordinating and reporting on the program authorized by Section 107(b) of Public Law 91-611 to demonstrate the practicability of extending the navigation season on the Great Lakes and Saint Lawrence Seaway. It covers the Federal agencies participating in the program and their relations with other program participants

2. AUTHORIZATION

Section 107(b) of the 1970 Rivers and Harbors Act (P.L. 91-611) provides:

"The Secretary of the Army, acting through the Chief of Engineers, in cooperation with the Departments of Transportation, Interior, and Commerce, including specifically the Coast Guard, the Saint Lawrence Seaway Development Corporation, and the Maritime Administration: the Environmental Protection Agency; other interested Federal agencies, and non-Federal public and private interests, is authorized and directed to undertake a program to demonstrate the practicability of extending the navigation season on the Great Lakes and Saint Lawrence Seaway. Such program shall include, but not be limited to, ship voyages extending beyond the normal navigation season; observation and surveillance of ice conditions and ice forces; environmental and ecological investigations; collection of technical data related to improved vessel design; ice control facilities, aids to navigation; physical model studies; and coordination of the collection and dissemination of information to shippers on weather and ice conditions. The Secretary of the Army, acting through the Chief of Engineers, shall submit a report describing the results of the program to the Congress not later than July 30, 1974. There is authorized to be appropriated to the Secretary of the Army not to exceed $6,500,000 to carry out this subsection."

3. ORGANIZATION

The demonstration program will be carried out by elements of the Federal Government, other public agencies, and private entities as prescribed by law. The organization for management, coordination and reporting will be as shown on the chart in Inclosure #1.*

*Lead Agencies.* The investigation and demonstration activities under the program will be divided initially into seven program elements. One of the Federal agencies will be responsible as lead agency for execution of each program element, in accordance with the program assignments shown in Inclosure #1.* Each lead agency will carry out its element of the program with its own forces, with support from other govern-

*Organization chart is shown on page 30 of this report.

ment agencies, and by contract at its own discretion. The lead agency for each program element will form and chair a work group of representatives of all agencies participating in that program element, in order to establish definite points for coordination of program participation.

*Board.* A Board of senior field representatives of the participating Federal agencies and invited non-Federal public and private interests will coordinate planning, programming, budgeting, execution and reporting of investigations and demonstration activities. The Division Engineer, North Central Division, Corps of Engineers, will serve as Chairman of the Board. Board members will forward coordinated recommendations to their respective headquarters in Washington, where they will receive normal departmental review and interdepartmental coordination before transmittal by the Secretary of the Army to the Office of Management and Budget and the Congress.

*Working Committee.* A Working Committee of representatives of participating Federal agencies and invited non-Federal public and private interests will provide continuous coordination of program activities and will develop and coordinate plans, programs, budgets, schedules, work descriptions, and reports for consideration by the Board. The District Engineer, Detroit District, Corps of Engineers, will serve as Chairman of the Working Committee.

*Advisory Group.* An advisory group will be formed to provide broad representation from private interests in the planning and execution of the demonstration program. The Advisory Group will include representatives of industry, labor, consumers, and concerned citizens. The Advisory Group will name two of its members to serve on the Board and two representatives to serve on the Working Committee. Such representatives will serve on the Board and Working Committee for terms of one year and may be named to successive terms at the discretion of the Advisory Group. The Board and the Working Committee will consult the Advisory Group to obtain proposals for demonstration activities, recommendations on the conditions under which extended season navigation should be carried out, and the results of the demonstration program each year for all affected private interests.

## 4. FUNDING

Funding of investigations and demonstration activities will be both by appropriations under authority of Section 107(b), PL 91-611, and by separate appropriations of the various participating agencies and interests. The Working Committee will assemble a coordinated budget showing the agency requests for funds from demonstration program appropriations and the amounts which agencies propose to expend from their own separate appropriations for activities directly related to the demonstration program. The preparation of a coordinated budget is not intended to infringe on any agency's freedom to use its own funds, but justification of requests to Congress for appropriations must be based upon a full revelation of the various sources of funds supporting the total program.

The Board will review the coordinated budget request and forward its recommendation to the Office of the Chief of Engineers for incorporation in the Corps of Engineers civil works budget. Other agencies may defend their separate appropriations for demonstration activities based upon the budget recommendations of the Board.

Demonstration program appropriations will be allocated to participating agencies in accordance with the recommendations of the Board. Upon apportionment by the Office of Management and Budget, the funds for the demonstration program appropriated under the authority of Section 107(b), PL 91-611, will be allotted to the Detroit District by the Office of the Chief of Engineers. The District Engineer, Detroit District will furnish to each lead agency a reimbursable agreement in the amount approved by the Board. Reimbursement for expenditures will be based on billings from each lead agency to the Detroit District.

## 5. PUBLIC INFORMATION

Success of the demonstration program depends upon an effective public information program to explain the objectives and the issues involved in extension of the navigation season on the Great Lakes and the Saint Lawrence Seaway. The Working Committee will serve as the means of coordinating public information activities of all program participants, subject to policy guidance from the Board. Each agency represented on the Working Committee will advise the Chairman of the Working Committee when his agency proposes making public announcements or undertaking other significant public information activities related to the demonstration program. The Working Committee Chairman will notify the other agency representatives of such announcements or activities, for their advance information.

Public meetings for the purpose of public participation in the demonstration program will be conducted jointly by the participating agencies under the policy guidance of the Board.

U.S. ARMY CORPS OF ENGINEERS

NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION

MARITIME ADMINISTRATION

ENVIRONMENTAL PROTECTION AGENCY

Francis T. Mayo

MAR 28, 1972

U.S. COAST GUARD

C R Bender

DEPARTMENT OF THE INTERIOR

Rogers C B Morton

MAR 16 1972

SAINT LAWRENCE SEAWAY DEVELOPMENT CORPORATION

March 23, 1972

FEDERAL POWER COMMISSION

## PARTICIPATING AGENCIES

United States Army Corps of Engineers

St. Lawrence Seaway Development Corporation

United States Coast Guard

National Oceanic and Atmospheric Administration

Maritime Administration

U.S. Department of the Interior

Great Lakes Basin Commission

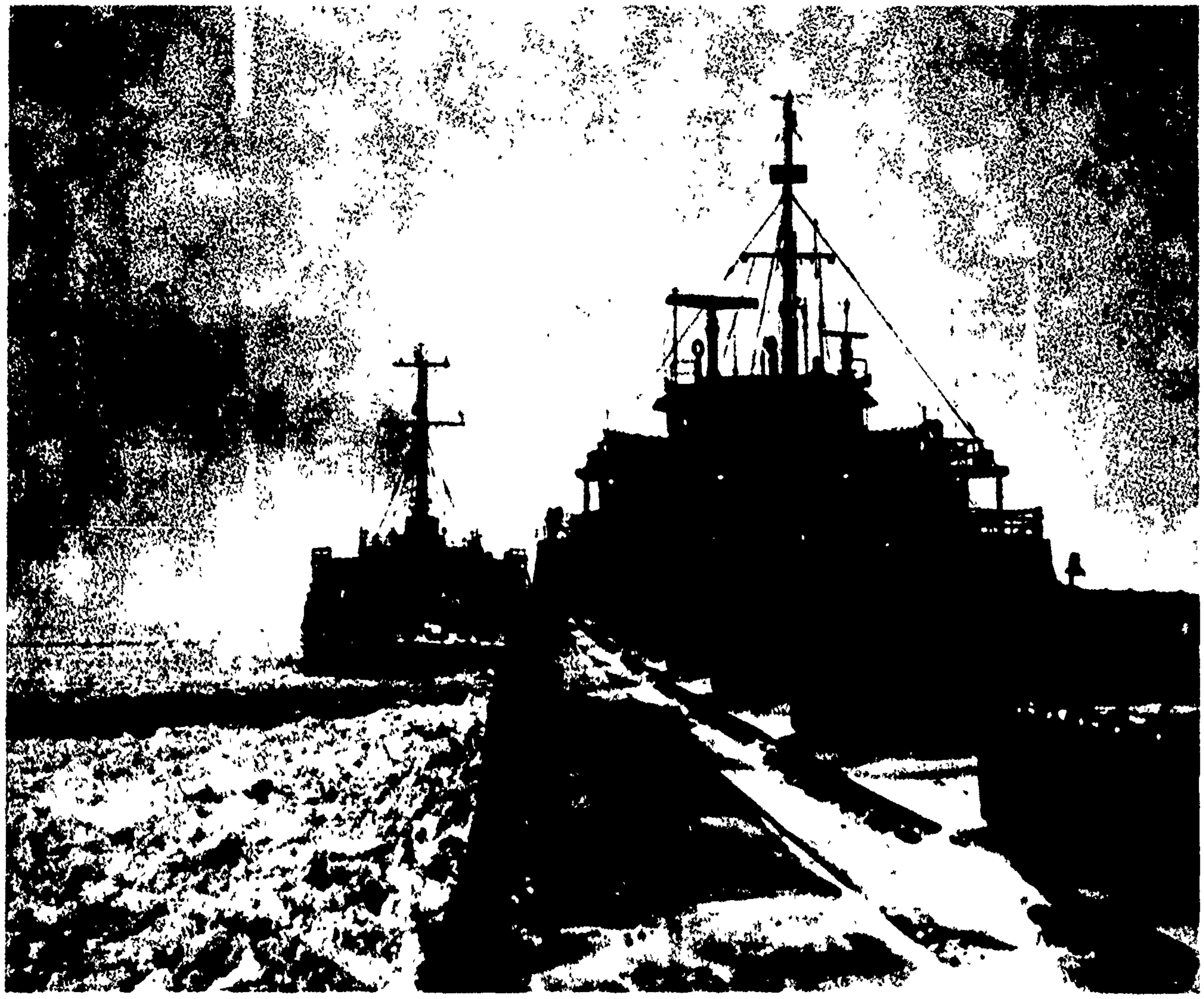
Great Lakes Commission

Environmental Protection Agency

Federal Energy Regulatory Commission

TECHNICAL ADVISORS: National Aeronautics and Space Administration (NASA) and
Energy Research and Development Administration (ERDA)
ADVISORY GROUP: Industry/Labor
OBSERVERS: Saint Lawrence Seaway Authority of Canada
Canadian Coast Guard
International Joint Commission
U.S. Department of State

**GREAT LAKES AND ST. LAWRENCE SEAWAY**
**NAVIGATION SEASON EXTENSION DEMONSTRATION PROGRAM**



# The Great Lakes and St. Lawrence Seaway Winter Navigation Board

## Demonstration Program Final Report

September 1979

## WINTER NAVIGATION BOARD

*Voting Members*

*Participating Agencies*

UNITED STATES ARMY CORPS OF ENGINEERS (CHAIRMAN)
UNITED STATES COAST GUARD (VICE-CHAIRMAN)
ST. LAWRENCE SEAWAY DEVELOPMENT CORPORATION
MARITIME ADMINISTRATION
FEDERAL ENERGY REGULATORY COMMISSION
U.S. DEPARTMENT OF THE INTERIOR
GREAT LAKES BASIN COMMISSION
GREAT LAKES COMMISSION
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
ENVIRONMENTAL PROTECTION AGENCY
GREAT LAKES STATES REPRESENTATIVE

*Private Interest Advisory Group*

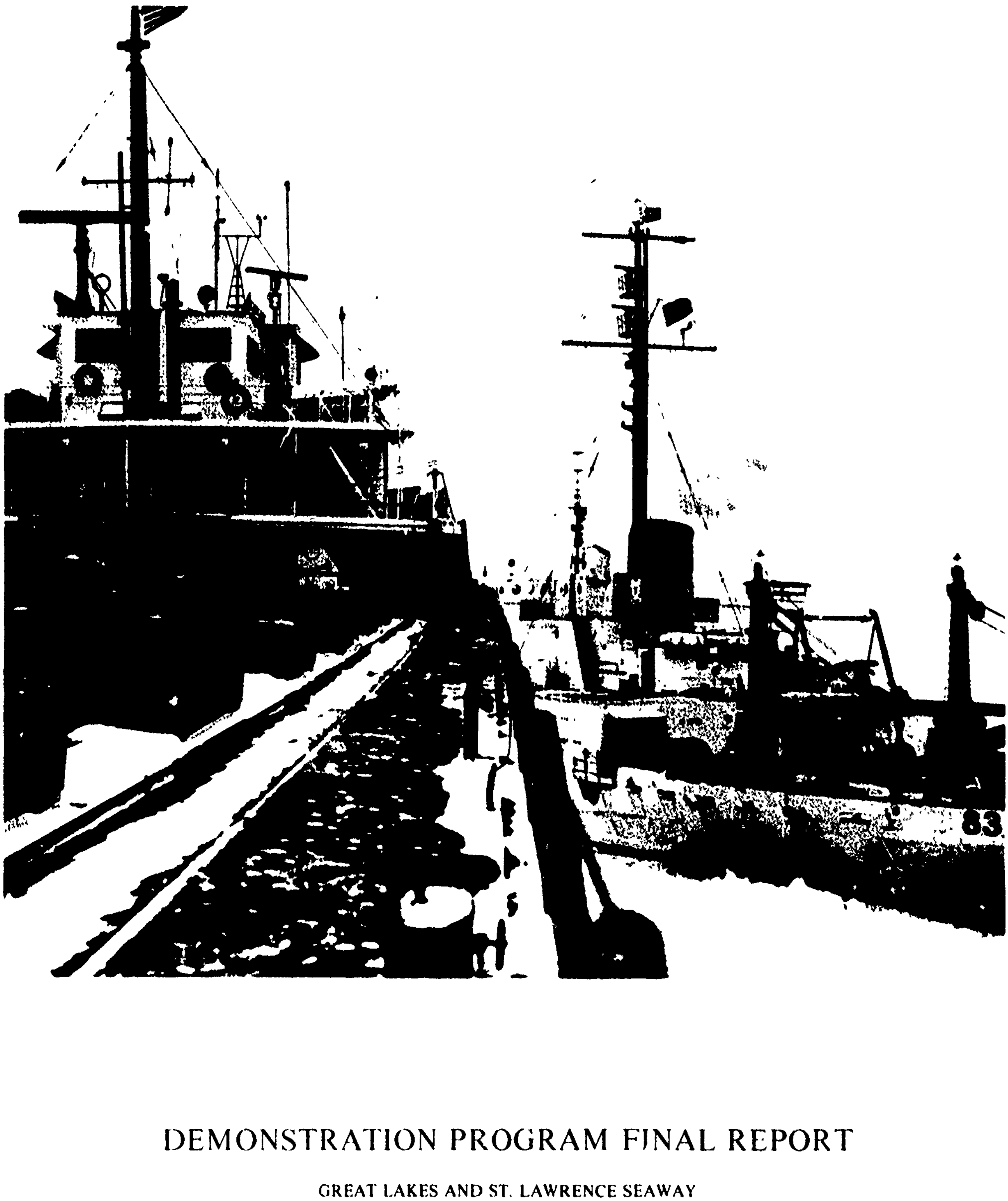
LAKE MARINE ENGINEERS BENEFICIAL ASSOCIATION
GREAT LAKES TASK FORCE

*Observers*

ST. LAWRENCE SEAWAY AUTHORITY OF CANADA
CANADIAN COAST GUARD
INTERNATIONAL JOINT COMMISSION
U.S. DEPARTMENT OF STATE

*Technical Advisors*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION




# DEMONSTRATION PROGRAM FINAL REPORT

GREAT LAKES AND ST. LAWRENCE SEAWAY

WINTER NAVIGATION BOARD

September 1979

GREAT LAKES AND ST. LAWRENCE SEAWAY
WINTER NAVIGATION BOARD

*Chairman*
**Major General Richard L. Harris**
United States Army Corps of Engineers

*Vice Chairman*
**Rear Admiral Anthony Fugaro**
United States Coast Guard

*Members*
**Honorable David W. Oberlin**
St. Lawrence Seaway Development Corporation

**Mr. George J. Ryan**
Maritime Administration

**Mr. James D. Hebson**
Federal Energy Regulatory Commission

**Mr. Harvey K. Nelson**
U.S. Department of the Interior

**Ms. Lee Botts**
Great Lakes Basin Commission

**Mr. Clifford H. McConnell**
Great Lakes Commission

**Rear Admiral Harley D. Nygren**
National Oceanic and Atmospheric Administration

**Dr. Edith J. Tebo**
Environmental Protection Agency

**Mr. William D. Marks**
Great Lakes States Representative

*Private Interests Advisory Group*
**Mr. Melvin H. Pelfrey**
Lake Marine Engineers Beneficial Association

**Mr. John A. McWilliam**
Great Lakes Task Force

*Observers*
**Mr. Walter E. Webb**
St. Lawrence Seaway Authority of Canada

**Mr. Leon Germain**
Canadian Coast Guard

**Mr. Stewart H. Fonda, Jr.**
International Joint Commission

**Mr. Sidney Friedland**
U.S. Department of State

*Technical Advisors*
**Dr. Herman Mark**
National Aeronautics and Space Administration

**Dr. George Saunders**
Energy Research and Development Administration

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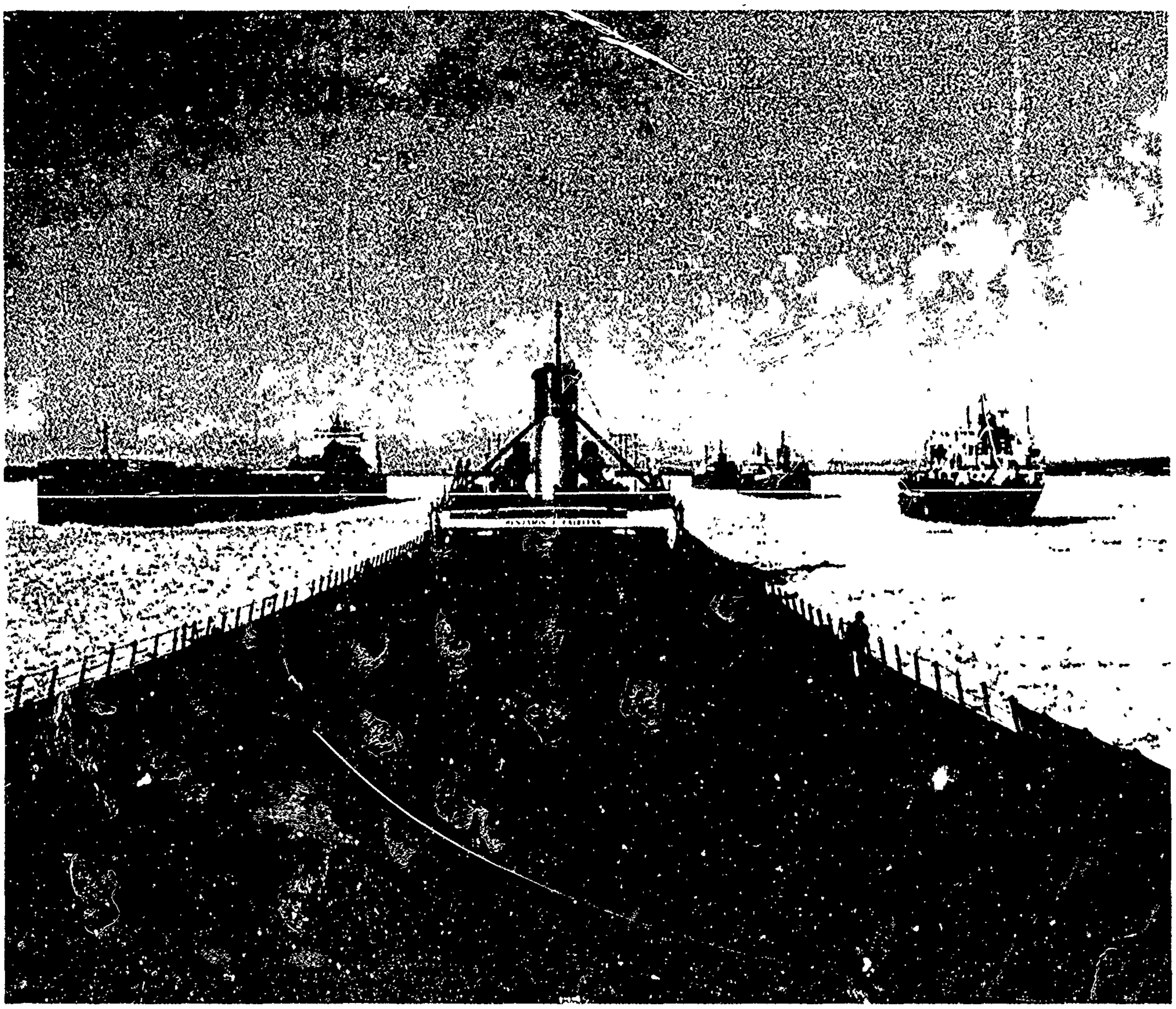
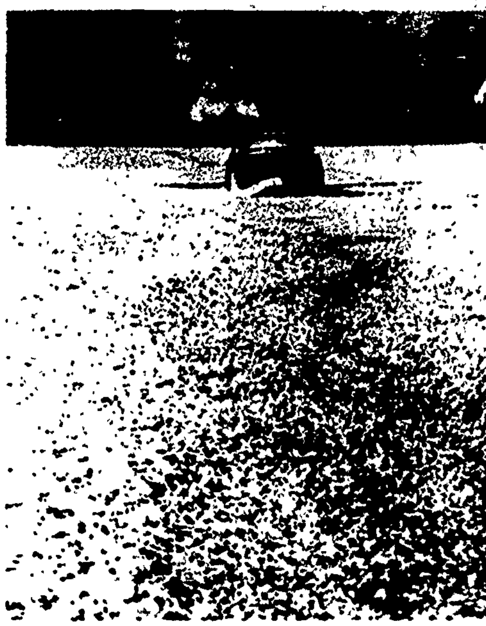


*Convoy in ice.*

# PREFACE

*Vessel moves through ice field.*



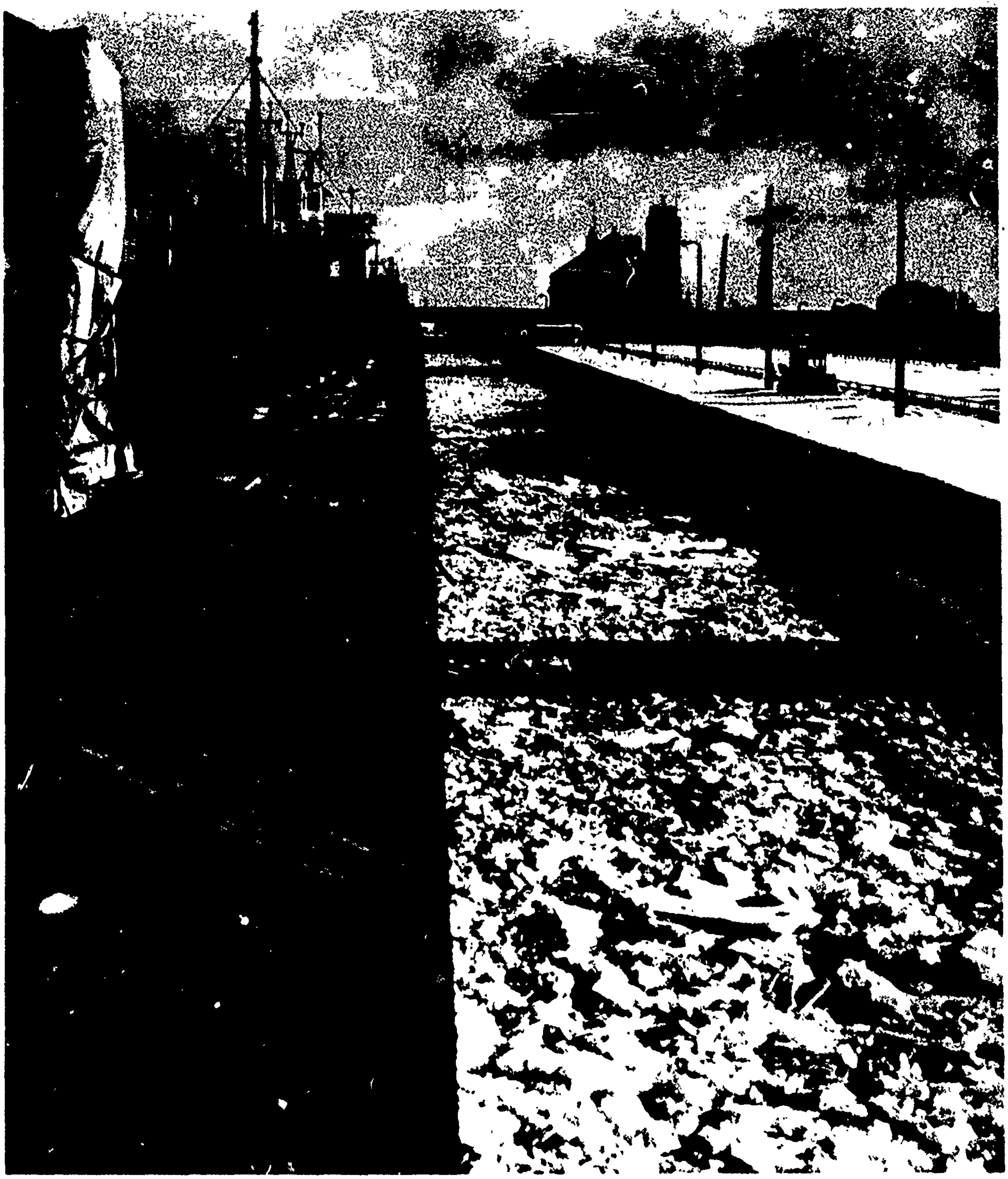
The Great Lakes and St. Lawrence Seaway Navigation Season Extension Demonstration Program is authorized by Congress in the River and Harbor Act of 1970 (Public Law 91-611), amended by the Water Resources Development Acts of 1974 and 1976 (Public Laws 93-251 and 94-587, respectively). This program was undertaken to demonstrate the practicability of extending the navigation season on the Great Lakes and St. Lawrence Seaway System. It is important to note that while the program and study are in response to specific legislation by Congress, participating Federal agencies have continuing responsibilities for development of ice control measures; these are funded and carried out under normal mission activities, funded under individual agency programs. These programs are discussed in this report, but not distinguished from Demonstration Program activities. Costs of normal mission activities are not included in specifically authorized program funding.

At the onset of the program, preliminary conclusions existed which indicated that engineeringly feasible measures were already available to extend the navigation season. In authorizing the program, Congress provided a means to verify these conclusions and to demonstrate the practicability of extending the navigation season.

This and previous reports on the Demonstration Program confirm that many of the originally stated conclusions are correct: Technical measures presently exist which are effective in extending the traditional navigation season and they involve varied economic, social and environmental impacts. They are discussed in this report.

This report is the last in a series dealing with demonstration activities undertaken or studied to facilitate commercial vessel operation on the Great Lakes and St. Lawrence Seaway. Activities conducted during the first five years of the program were described in some detail in the Winter Navigation Board's previously published reports. This report summarizes the activities, results, and conclusions reached during the eight years of the Demonstration Program.

The results of the demonstration activities are a primary data source for and are supportive of the Survey Study currently being conducted by the U.S. Army Corps of Engineers. The Survey Study is to identify the costs, economic benefits, engineering feasibility, and the social and environmental acceptability of extending the navigation season. The Report is provided at the direction of Congress to assist in determining the Federal interest in a permanent navigation season extension on the Great Lakes and St. Lawrence Seaway System.



*Looking toward Soo Locks.*

# THE WINTER NAVIGATION BOARD SUMMARY REPORT

Fiscal Year 1979 was the final year of a program to demonstrate the practicability of various means of extending the navigation season on the Great Lakes-St. Lawrence Seaway System. This executive summary abstracts the most important aspects from the full report on program activities and achievements accomplished under the Demonstration Program.

## Part I: Background and Perspective

*The need*

The Great Lakes-St. Lawrence Seaway System is a deep draft waterway which provides a means of energy efficient, low cost marine transportation to the U.S. heartland -- a 19-state economic hinterland area which generates some 41% of the nation's personal income.

Agriculture, mining, petroleum refining, and the manufacture of both durable and non-durable goods are important industries within the area. The need for the movement of both bulk raw materials and finished products is substantial.

Historically, however, in mid-December, the waterborne link of the regional transportation system has closed down for up to four months due to weather and ice conditions ... remaining closed until early April, when conditions again permitted transit, without assistance.

Industry in the region relying on bulk materials has adapted to the closed season by stockpiling, a costly process and by the use of more costly modes of transportation. At the same time, a large portion of the Great Lakes fleet halts operation and lays up, resulting in increased yearly operational costs to the owners because the vessels are not producing income, but the fixed costs (depreciation, vessel cost, etc.) are still paid. These costs show up during the active shipping season which must be passed along to the shipper during the balance of the season and ultimately to the public in increased product cost.

The close of the Great Lakes-St. Lawrence Seaway shipping season by winter weather conditions also has a negative impact on employment: lay-offs occur. Some of the Nation's largest ports close down, and capital-intensive cargo handling equipment is idled.

In the past, extraordinary circumstances such as steel strikes (1956 and 1959), and at times of national emergency (January, 1945), operations at the locks at Sault Ste. Marie, Michigan, continued into the winter months to accommodate the urgent needs of the Nation for Great Lakes shipping. These circumstances indicated even then that certain types of winter navigation activities were at least engineeringly feasible.

*Prior study*

In recognition of the need to investigate potential benefits of an extended navigation season, Co..gress in

the 1965 River and Harbor Act *(Public Law 89-298)* authorized the U.S. Army Corps of Engineers to conduct a limited study into the feasibility for extending the season.

After a review of world-wide experience in ice navigation and ice modification techniques, this study concluded that the present state of technology was sufficiently advanced to make winter operation on the Great Lakes-St. Lawrence Seaway System physically feasible. The extent to which winter operation should be undertaken, and the economic feasibility for either limited or year-round extension, could not be determined on the basis of the limited investigations made in that study.

Traffic projection and estimated benefits clearly demonstrated sufficient economic potential to warrant further investigation. The initial feasibility study identified means by which problems associated with an extended navigation season on the Great Lakes-St. Lawrence Seaway System might be eliminated, and recommended that a full-scale study be undertaken.

*Current program authority*

The Great Lakes and St. Lawrence Seaway Navigation Season Extension Program is authorized by Congress in Section 107 of the River and Harbor Act of 1970 (Public Law 91-611). This authority is cited in its entirety on page 134. Section 107b has been amended twice since 1970. The program consisted of three parts, the Survey Study, the Demonstration Program, and the Insurance Study as follows:

*1. Survey Study:* A detailed survey study is underway to determine the economic justification, engineering practicability, and potential environmental and social impacts of an extended navigation season. This in-depth study is being conducted by the U.S. Army Corps of Engineers with input from the Winter Navigation Board. The results of the Survey Study would provide the basis for Congress to determine the Federal interest in providing means for an extended navigation season on the Great Lakes and St. Lawrence Seaway. An interim Survey Report was submitted to the Board of Engineers for Rivers and Harbors in March 1976 recommending a limited season extension on the upper four Great Lakes (Superior, Michigan, Huron and Erie) to 31 January (± 2 weeks), utilizing for the most part basic operation measures and existing facilities. This Interim Report has been transmitted to Congress on 3 August 1979.

The final Survey Report, addressing several options up to a 12-month season on the system is un-

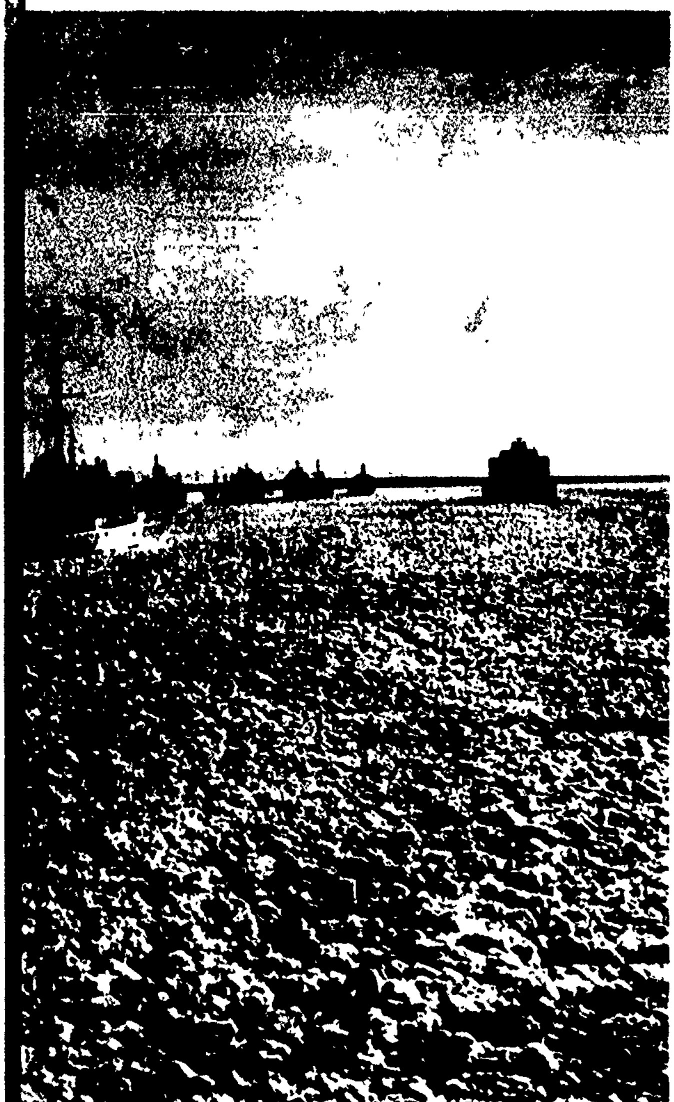
derway. The Survey Report would provide the results of the study and suggest additional measures which would be required beyond those previously recommended.

2. *Demonstration Program:* Through the Congressionally mandated action-oriented Demonstration Program the U.S. Army Corps of Engineers was directed to demonstrate the practicability of extending the navigation season on the Great Lakes-St. Lawrence Seaway System. Federal legislation directed the Secretary of the Army, acting through the Chief of Engineers, to carry out this program in cooperation with affected Federal agencies and non-Federal public and private interests.

The actions of the Winter Navigation Board in concert with private navigation interests have resulted in substantial extensions of the normal navigation season on the upper four Great Lakes in each of the eight years of the program. Year-round shipping was actually achieved in the upper four Great Lakes during four of the eight years of the Demonstration Program.

Modeling was conducted both before and in addition to actual physical methods for extending the season in the St. Lawrence Seaway.

This report, describing the results of the Demonstration Program, is submitted in compliance with the legislation.

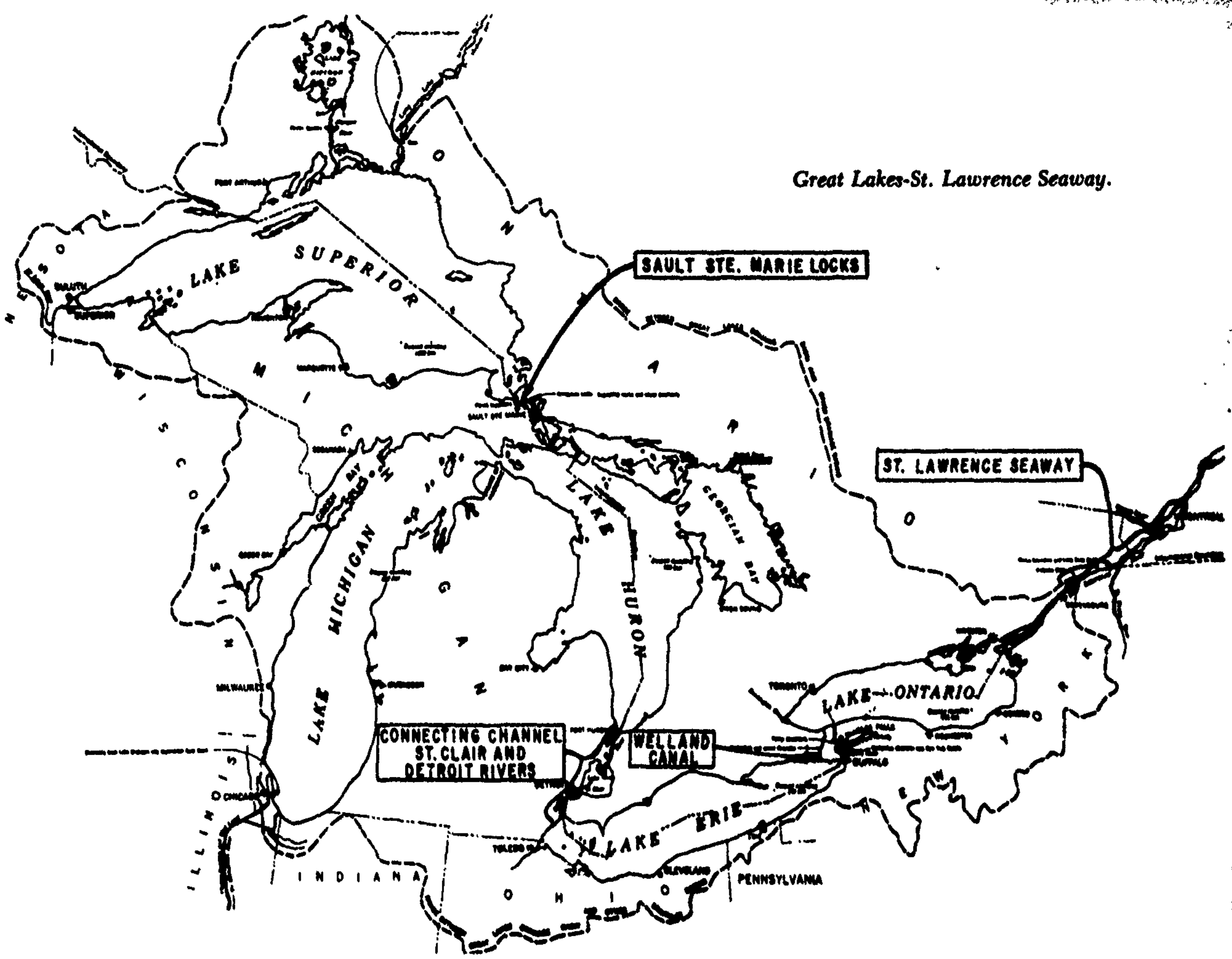


*View of convoy.*

3. *Insurance Study:* The Secretary of Commerce, acting through the Maritime Administration, was directed to conduct a study to determine the means by which reasonable insurance rates could be provided for shippers and vessels engaged in waterborne commerce beyond the traditional navigation season. The Maritime Administration completed the study in 1972 and found insurance rates, although higher for the extended season, are not a major impediment to winter navigation. As the Demonstration Program proceeded, insurance underwriters redefined late sailings so that rate increases did not take effect until substantially later in the season.

*The geographic/economic region*

A brief glance at the geography of the Great Lakes-St. Lawrence Seaway waterway is helpful to an understanding of both the opportunities and the challenges implicit in winter navigation. The Great Lakes and their connecting channels contain a water surface area of over 95,000 square miles, of which about 61,000 square miles are within United States boundaries. The Great Lakes Basin comprises a large




*Great Lakes-St. Lawrence Seaway.*

area of over 300,000 square miles, drained by the St. Lawrence River through the Gulf of St. Lawrence into the Atlantic Ocean.

The Great Lakes provide a waterway over which 100 billion ton-miles of waterborne freight pass each year. Many commercial harbors serve the region including some of the largest in the Nation and two of the five largest U.S. cities. The distance from Duluth, Minnesota, at the western end of Lake Superior, to the Atlantic Ocean is 2,340 miles.

The Great Lakes Basin covers about 4% of U.S. land areas and includes more than 14% of the Country's population. One-sixth of the national income is earned in this region. Within the Canadian portion of the Great Lakes and St. Lawrence River Basin, the proportion of total population and economic activity is in excess of 60% of Canadian national totals.

The intra-region's transportation system, the Great Lakes, is critical in bringing raw materials from their sources in the upper lakes to industrial centers such as Chicago, Detroit, Cleveland, and Buffalo.

The St. Lawrence River connects the Great Lakes with the Gulf of St. Lawrence on the North Atlantic Ocean. Since the international portion of the St. Lawrence River extends from Lake Ontario to a point below Massena, New York, the Demonstration Program activities pertain to this reach which is under the joint navigational control of the St. Lawrence Seaway Development Corporation, a corporate agency of the United States Government, and the St. Lawrence Seaway Authority of Canada. Below the international section, the river and the remaining Seaway locks lie entirely in Canada. Year-round navigation from the Ocean to Montreal has been an

operational reality for many years due to Canadian efforts to extend the navigation season at that end of the St. Lawrence River.

*The Great Lakes fleet*

Completion of the 1,200' x 110' Poe Lock at Sault Ste. Marie in 1968 strengthened the economics of high volume, low cost waterborne transportation on the Great Lakes. The construction of several 1,000' x 105' self-unloading bulk carriers -- and several more under contract at Great Lakes shipyards -- has dramatically changed the future direction of the Great Lakes shipping fleet. A period of accelerated change in the size and shape of Great Lakes vessels is emerging as this new generation of larger, more sophisticated and more costly vessels move in to dominate roles in the ore and coal trades.

*Winter navigation problems in perspective*

Ice and its effects are the major physical impediments to winter navigation. On the Great Lakes, ice conditions are most severe in the upper four lakes and connecting channels: the St. Marys River between Lakes Superior and Huron; the Straits of Mackinac connecting Lakes Michigan and Huron; and the St. Clair and Detroit Rivers linking Lakes Huron and Erie. These connecting channels and the St. Lawrence River form natural constrictions in which the potential for ice jams and other problems implicit to winter navigation are most severe.

Icebreakers can open and maintain vessel tracks. However, sophisticated ice management techniques are needed to maintain stable ice fields and facilitate commercial ship movement in these channels and in harbors. The development of ice control techniques

**SELF-PROPELLED VESSELS OF 1,000 GROSS TONS AND OVER AS OF NOVEMBER 24, 1978**

**U.S. GREAT LAKES FLEET**

| TOTAL ALL VESSELS | BULK CARRIERS | | TANKERS | | OTHERS[1] |
|---|---|---|---|---|---|
| | # | DWT | # | DWT | # |
| 159* | 143* | 2,848,825* | 6 | 40,643 | 10 |

[1]Railroad Cars-Passenger Car Ferries
Source: Maritime Administration, Great Lakes Region
Greenwood's Guide to Great Lakes Shipping
*Includes integrated tug-barge "Presque Isle" of 52,000 DWT, which, for operations purposes, is considered a vessel.

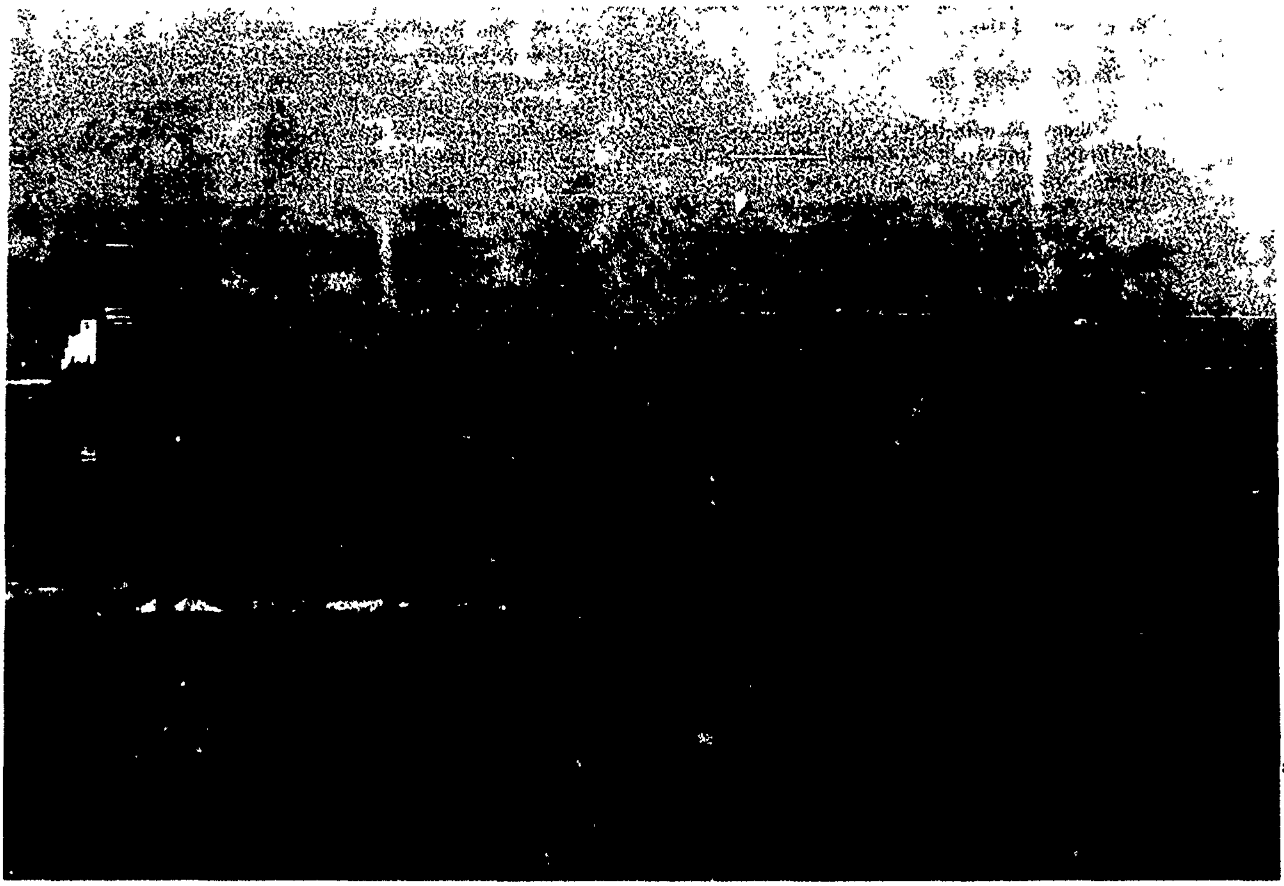
As part of its ongoing program, as mandated by Executive Order of 1936, the U.S. Coast Guard's Ninth District headquartered at Cleveland, Ohio, provides icebreaking support to vessels beset in ice or in need of assistance to transit through the ice. For this task, and other assigned missions, the Coast Guard employs a fleet of twelve vessels year round including one major icebreaker. During the Demonstration Program an additional icebreaker was added for winter operation.

On 8 January 1979, the *Katmai Bay*, the first in a series of four new class icebreaking tugs to be received before the winter of 1979-80, was commissioned. The new vessels, replacing an older class, will greatly upgrade Coast Guard icebreaking capabilities in the Great Lakes.

which will permit winter navigation while maintaining unimpeded river flow, for instance, is especially important on the St. Lawrence River. Here, ice booms have been installed at specific locations on the Seaway to assist in the development and maintenance of a stable ice cover, to prevent ice jams, avoid flooding, and assure an uninterrupted flow for the regulation of lake and river water levels and the production of hydroelectric power. These booms are closed each year after the close of navigation.

Proposals for extending the navigation season have raised many questions concerning environmental impacts, particularly in the connecting channels and harbors, and in the St. Lawrence River. It has become evident that extensive environmental studies would be

*The 1,000-foot carrier* James R. Barker *heads through ice towards the Soo.*



required if an environmental baseline were to be established. Such a baseline would allow for monitoring to detect and determine the extent of environmental impacts which might occur as a result of an extended season. Particular concern has been expressed over the possibility of oil spills in winter conditions and the organizational and technical capacity of both the government agencies and private industry to adequately react to that situation. The possibility of increased shoreline and structure damage resulting from the extended navigation season is also a major concern.

Other stated concerns over extended season operations include island access difficulties and the disruption of established recreation patterns, which might lead to declines in tourism.

Since conventional floating navigational buoys are removed prior to ice formation, the need arises for an all-weather navigational aid system to reduce the risk of groundings and collisions and to permit 24 hour navigation. Related to this are the needs for a network to collect and disseminate ice and weather data and the development of improved prediction techniques for ice freeze-up and break-up periods.

The safety of vessels and crews during winter season operation is also a primary concern. In the event of accidents on the system, it is important that an effective emergency locating system be implemented for both vessels and crew members and that safety and survival equipment for crew members exposed to icy waters be improved.

The location of the waterway between the United States and Canada requires that a cooperative effort be undertaken to obtain the implementation of an extended season. The Welland Canal, navigation link between Lakes Erie and Ontario, and the lower reaches of the St. Lawrence River are wholly in Canada, and therefore Canada needs to determine its interest in extended season navigation and the nature of its commitment.

*Winter navigation accomplishments in perspective*

In eight years of extended season tests and ice breaking operational activities, the Coast Guard has demonstrated the practicability of continuous commercial traffic under adverse winter ice conditions. Additionally, and in concert, many ice control and ice management concepts and methods were tested by the Corps of Engineers and other participating agencies; the most successful of which are briefly mentioned in this section, and described in the text that follows. Bubbler systems and the use of thermal effluents were tested for effectiveness in reducing ice cover. Model studies were conducted to gain insights into the effects of vessel transits on water levels and flows in the St. Marys, St. Clair, and St. Lawrence Rivers, and to test the effectiveness of different types of ice control structures.

Limited environmental studies were conducted to determine the effects of specific Demonstration activities on the environment, such as the effect of long line bubblers on fish movement, and some baseline data were collected, principally on the St. Marys River. The U.S. Coast Guard developed an Oil and Hazardous Substance Spill Contingency Plan and tested new methods and devices for oil spill containment and recovery. These activities were independent from the Demonstration Program.

To facilitate transportation to islands in the St. Marys River, the U.S. Army Corps of Engineers made and tested substantial improvements to the Sugar Island ferry and provided an air boat for use and testing by Lime Island residents. Studies were conducted along proposed vessel routes to determine possible impacts on recreational activities.

To enhance the safety of navigation under conditions of poor visibility, several systems have been tested under various authorities. They include the installation of a magnetic wire on the channel bottom, a laser light range, a radar navigation system, radar transponder beacons (RACONs) and a limited Long Range Navigation (mini Loran-C) system in the St. Marys River. Prototype ice buoys were tested as replacements for regular light and radar buoys which are removed prior to ice conditions.

The U.S. Army Corps of Engineers and the St. Lawrence Seaway Development Corporation (SLSDC) gathered data on ice and weather conditions throughout the Great Lakes. This information was channeled through the Coast Guard's Ice Navigation Center in cooperation with reporting stations established by the National Weather Service. These units provide up-to-date information on ice and weather conditions, including ice forecasts (from techniques developed by the Great Lakes Environmental Research Laboratory), ice outlooks and ice charts in support of extended season shipping.

The U.S. Coast Guard also has tested several survival suits, survival craft and position-indicating transponders for emergency use by vessel crews. Both survival suits and position indicating transponders have been adopted by vessel operators.

Canadian interests have been represented on the Winter Navigation Board as observers since the inception of the program. A Joint U.S. and Canadian Guide for Icebreaking was developed and implemented independently from the Demonstration Program. Additionally, direct coordination between the St Lawrence River operating agencies (e.g., St. Lawrence Seaway Development Corporation and St. Lawrence Seaway Authority) has occurred throughout the program. Canadian vessels have operated on the Great Lakes later into the season as a result of extended navigation season measures and the St. Lawrence Seaway Authority has made improvements in the Canadian portion of the Seaway to facilitate operation in ice conditions.

*Unresolved winter navigation issues*

One of the stated goals of the Demonstration Program was the accomplishment of vessel transit tests, under severe winter ice conditions, in the St. Lawrence River. Notwithstanding that many ice control measures, tests, and investigations have been carried out in the eight years of Demonstration Program, activities, including limited vessel transit of ice booms, the desired goal could not be accomplished.

Unresolved issues include the model predictions of effects on the level of Lake Ontario and flows in the St. Lawrence River. Disruption of these flows have potential impacts on power production. Associated with flows and disrupted ice conditions are many environmental questions which numerous private and State groups in New York, including the Governor, feel need to be addressed before any demonstration oc-

curs. Concern has also been raised that the demonstration activities cannot proceed without formal coordination and approval of the Canadian Government.

These critical issues affecting vessel transit tests on the St. Lawrence River, were addressed by the Winter Navigation Board in a resolution passed by a 9 to 4 split vote on 11 January 1979:

Be it resolved that:

1. The Chairman, on behalf of the Winter Navigation Board, shall communicate to Congress the sense of the Board regarding the Winter Navigation Season Extension Demonstration Program, through the Chief of Engineers and the Secretary of the Army, to the effect that the Board:

2. understands its obligation to provide to the Congress timely recommendations on its findings and conclusions concerning the demonstration program and the public funds appropriated for its support,

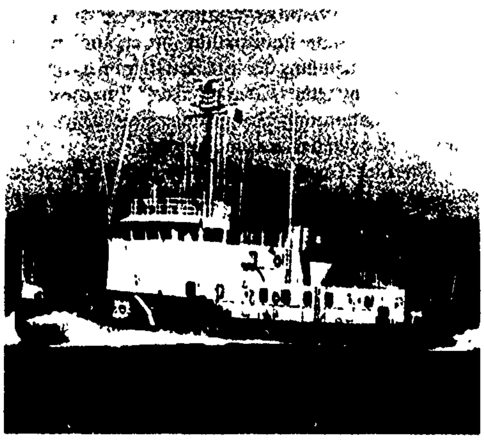
3. understands the purpose of the season extension Demonstration Program is to demonstrate the practicability of navigation on the Great Lakes and St. Lawrence Seaway System during conditions of ice cover,

4. wants to be responsive to the concerns of environmental and conservation interests in the conduct of a season extension demonstration program,

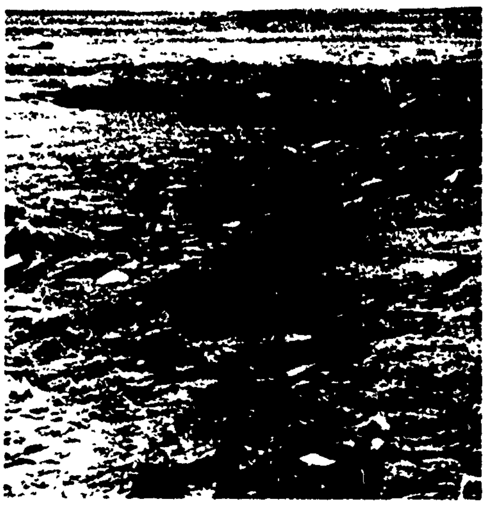
5. recognizes that it cannot achieve agreement between the various interested parties with regard to the environmental and ecological investigations, including an investigation of measures necessary to ameliorate any adverse impacts upon local communities, requisite to demonstration on the St. Lawrence River, and that demonstration of winter navigation on the St. Lawrence River will not be possible within the current authorization of Section 107(b), P.L. 91-611,

6. recognizes that the time and financial constraints which the Congress placed on demonstration program activities prevents undertaking exhaustive environmental baseline studies, however justified such studies might be for post-authorization activity,

and, further, that the Board:



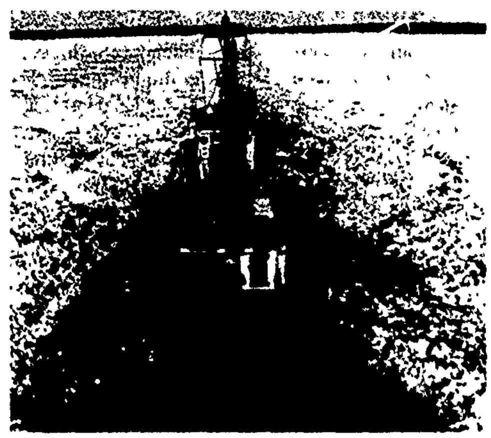
*The new 140-foot Coast Guard Cutter* Katmai Bay.



*Pack ice in Lake Superior.*

7. believes, on the basis of actual experience and operational activities on the upper Great Lakes and the lower St. Lawrence River, on the basis of the 1976 Interim Survey Report, that substantial evidence exists to support a finding of technical and economic feasibility, except on environmental matters in the St. Lawrence River,

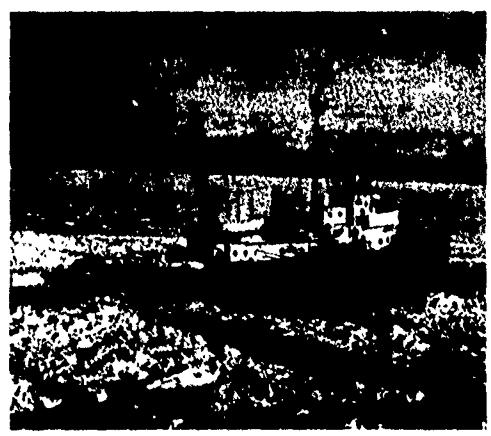
8. recommends either: (a) a substantial extension of the Demonstration Program on the St. Lawrence River to accommodate the stated environmental objections; or, (b) that as an alternative to further demonstration on the St. Lawrence River, which cannot be accomplished under current authorization, and in order to comply fully with the investigative request of Congress, that the feasibility report scheduled for completion in FY 1980 under Section 107(a), P.L. 91-611, include provisions recommending post-authorization accomplishment of the St. Lawrence River demonstration program objectives, particularly development of navigable ice booms, vessel transit tests, and investigation of measures necessary to ameliorate any adverse impacts upon local communities,



*Aft view of the* Naugatuck.

9. supports the early completion of the final feasibility report and its expedient processing to the Congress, while recognizing that any additional environmental studies which Congress deems necessary may be authorized and funded through an extension of the demonstration program, or some other directive,

10. recommends that remaining unobligated funds in the demonstration program, as appropriate and to the extent necessary, be used to assure completion of the feasibility report and to initiate action suggested by agencies, as approved by the Board, as prerequisite to carrying out planned demonstration activities in the St. Lawrence under current authority.



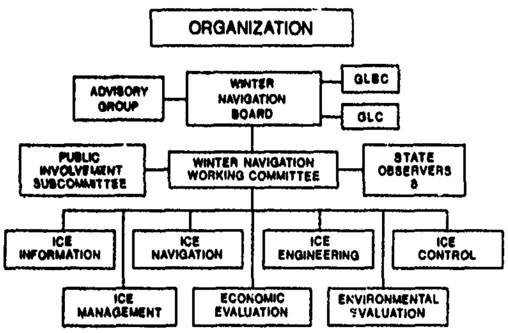
*The* Raritan *in heavy ice.*

## Part II: The Demonstration Program: A Final Report

### *Organization*

The chart on page 30 portrays the organizational structure of the Winter Navigation Board. Under the terms of a Memorandum of Un-

derstanding (see page 135) signed by the participating Federal agencies, the Great Lakes Basin Commission (GLBC) and the Great Lakes Commission (GLC), the Winter Navigation Board (established in July 1971) prescribed the organization and procedures for managing, coordinating and reporting on the Demonstration Program. The Board is composed of interested Federal and regional agencies, an industry and a labor representative, an Advisory Group formed to provide input from shipping and industrial interests, port authorities, and other non-Federal public and private interests, and a Great Lakes representative for all the Great Lakes States. Observers to the Board include the International Joint Commission, the Department of State, and from Canada, the St. Lawrence Seaway Authority and the Canadian Coast Guard. Technical advisors to the Board represent the National Aeronautics and Space Administration and the Energy Research and Development Administration.




A working committee, constituted similarly to the Winter Navigation Board, has carried out the program activities approved by the Board. Seven work groups, each headed by a lead agency and assisted by associated agencies, have conducted activities in their functional area. Also, attached to the working committee has been a public involvement subcommittee as well as state observers from each Great Lakes State.

*Strategic concept*

The impetus from private industry to engage in extended season shipping has been fundamental to the concept of the Demonstration Program. Activities under the program have been aimed at developing and, where possible, testing new or improved methods for facilitating commercial ship voyages. These activities have included finding solutions to winter navigation problems, the results of which have provided valuable input to the survey study.

Several principles formed the keystone of the Board's concept regarding both types and locations of activities undertaken:

1. A system approach has been essential in order to address all significant requirements of winter navigation on the Great Lakes-St. Lawrence Seaway System. High priority was assigned to the most significant requirements or problems.

2. While different conditions throughout the Great Lakes and St. Lawrence Seaway have required different solutions, methods or approaches tested have been adapted elsewhere in the system, wherever possible.

3. To assure validity of demonstrations, new techniques have been tested at the most difficult passage areas along major vessel routes, including the St. Marys River, the Straits of Mackinac, the St. Clair and Detroit Rivers and St. Lawrence River.

*Program funding*

Under the River and Harbor Act of 1970, $6.5 million were originally authorized for a three year demonstration program. The Water Resources Development Act of 1974 increased the amount to $9.5 million and extended the program 2½ years. The program was further extended another 2½ years and the funding increased to $15,968,000 by the Water Resources Development Act of 1976.

The Winter Navigation Board has allotted a total of $13,668,000 for the eight years of the program. These funds were distributed to the work groups for the various programs as shown in Table A. $2,300,000 were revoked, because time constraints precluded accomplishing several FY 79 activities in the St. Lawrence River.

*U.S.C.G.* Naugatuck *at Soo Locks.*

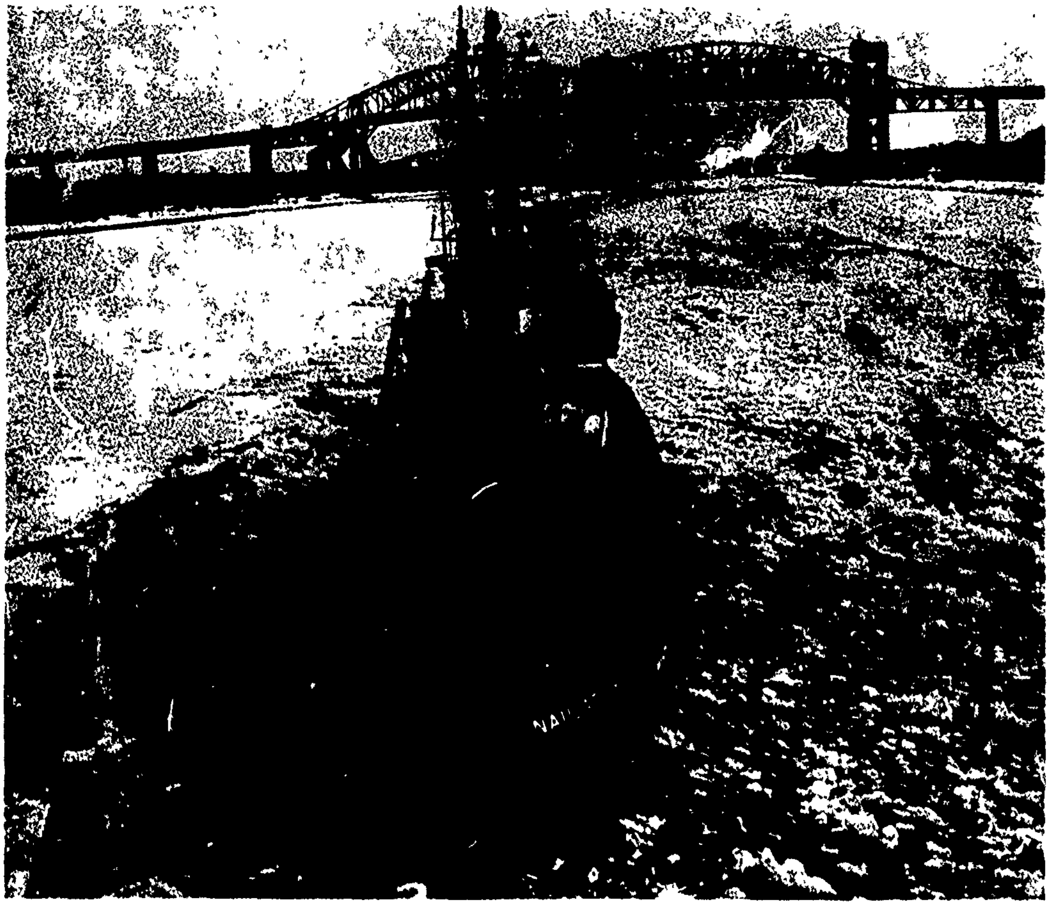


TABLE A

Demonstration Program Funding Allocation

| Program Element | Total FY 72 - FY 79 |
|---|---|
| Ice Information | $ 2,066,200 |
| Ice Navigation | $ 2,428,000 |
| Ice Engineering | $ 668,400 |
| Ice Control | $ 1,877,500 |
| Ice Management | $ 3,118,700 |
| Economic Evaluation | $ 143,900 |
| Environmental Evaluation | $ 1,609,600 |
| Program Management | $ 1,474,700 |
| Public Information Subcommittee | $ 93,200 |
| Reallocated to Survey Study | $ 187,800 |
| TOTAL | $13,668,000 |

*Taconite pellets.*

## Part III: Yearly Summaries of Activities FY 72-FY 79

*FY 72*

The first year's results were encouraging. When a U.S. ore carrier made the final transit of the Soo Locks in the St. Marys River on 1 February 1972, its passage marked the first time in history that commercial navigation between Lake Superior and the lower lakes had continued into the month of February.

Nearly 2,000,000 tons of cargo were shipped through the St. Marys River during the extended season, more than half of which was iron ore

Tests of a 3,000 foot air bubbler line placed on the River at a difficult turn in the channel by Lime Island proved successful in preventing the heavy ice formation which normally occurs at this bend. Several navigational aids indicated sufficient promise to warrant further testing under the program.

Much information was acquired on ice conditions throughout the system, and improved techniques were developed for collecting and disseminating such information and forecasting future ice conditions. Preliminary data was obtained on the pressures exerted by ice on structures.

Traffic continued on the St. Lawrence River above Montreal until 20 December 1971. After the close of the navigation season the power entities then completed closure of the two ice booms which cross the navigation channel in the International Section of the River. Designs for a movable gate in the Ogdensburg Boom were prepared in anticipation of a field test.

*FY 73*

The Great Lakes navigation season of 1972-73 through the St Marys River was again increased sub-

*Exiting the Soo Locks.*

stantially, running from 5 April 1972 through 8 February 1973. This was the second year the shipping season extended into February. Total tonnage through the St. Marys River during the FY 73 extended navigation season increased to 3.36 million tons, exceeding the previous year by over a million tons.

Extension of the navigation season on the St. Lawrence Seaway in 1972 stretched to 23 December. In addition, the relatively mild winter permitted the opening of the 1973 navigation season on 28 March, resulting in the shortest closed period in history both for the Seaway and the Locks at the Soo (8 February to 1 April).

Among FY 73 Demonstration Program activities were several carried over from FY 72. These were the operation of the Soo Locks as late as necessary for vessel transits (Corps), the operation of the Ice Navigation Center at Cleveland (Coast Guard), and the Ice and Weather Forecast Operation (National Weather Service).

Also continued from FY 72 were ice surveillance and aerial reconnaissance activities and provisions for transportation assistance for island residents. The ferry, *Sugar Islander,* was modified to improve its ice operating capabilities.

New activities conducted in FY 73 included the use of an airboat for transporting residents of Lime Island across the ice covered channel, the testing of experimental ice buoys and anchors, and the successful testing of RACONs and survival suits. Plans were prepared for testing a thermal discharge ice suppression system in Saginaw Bay.

In conjunction with the St. Lawrence Seaway Devel›pment Corporation's ongoing program, a prototype ice boom gate was installed at Ogdensburg, New York, but was not tested under ice conditions due to objections of the power entities involved. They desired to develop a stable ice cover as early as possible to protect power generating capabilities. The original boom, installed late each fall by hydroelectric power interests, assists in the formation and maintenance of a stable ice cover. The movable gate, as installed, used floating barges on which gate-operating equipment was mounted.

*FY 74*

The FY 74 Great Lakes navigation season through the St. Marys River was extended to 7 February 1974, the third consecutive year that the season was extended into February. The total tonnage shipped through the Soo Locks increased to 4.78 million tons for the extended season. The shipping season on the St. Lawrence was extended six days in December beyond the 16th. The St. Lawrence River achieved its earliest opening date during the program (26 March 1974).

Activities at the Ice Navigation Center were continued throughout the Demonstration Program in conjunction with ice surveillance and aerial reconnaissance activities and ice and weather forecasts.

Studies of ice conditions in the St. Marys River were carried out to determine the effects of winter navigation on shore erosion and shore structures. Continued testing of the ice buoys in the St. Marys and Detroit Rivers demonstrated their effectiveness in ice conditions. Results of tests of modified Radar Transponder Beacons (RACONs) and a Precise Laser/Radar Navigation System were encouraging.

Additional adaptation and testing of survival equipment were continued, and survival suits were distributed to vessel crews operating during the FY 74 extended season under ice free conditions. Tests of the gate installed in the Ogdensburg-Prescott ice boom were continued and two vessel transits were made in late November 1973.

The air bubbler system in Duluth-Superior Harbor was operated for evaluation of environmental impacts and system effectiveness. The airboat at Lime Island continued to provide and test transportation service for island residents. Preliminary plans for a thermal ice suppression facility in Saginaw Bay were prepared, detailed design of the facility was initiated, and baseline environmental data were collected to provide for evaluation of environmental effects.

The bubbler-flusher system at the mainland dock of the Sugar Island ferry prevented excessive ice buildup in the slip. Ice accumulations in Little Rapids Cut, however, continued to interfere with ferry service. A scope of work was prepared for a model study of ice conditions in Little Rapids Cut to be conducted in FY 75 to determine the most effective long-range solution to the problem.

Draft reports on two systems studies were completed, one for the St. Lawrence River and one for the St. Clair-Detroit Rivers System. The systems studies determined the probable modifications, structural measures, and associated costs for extension of the navigation season in these locations.

*FY 75*

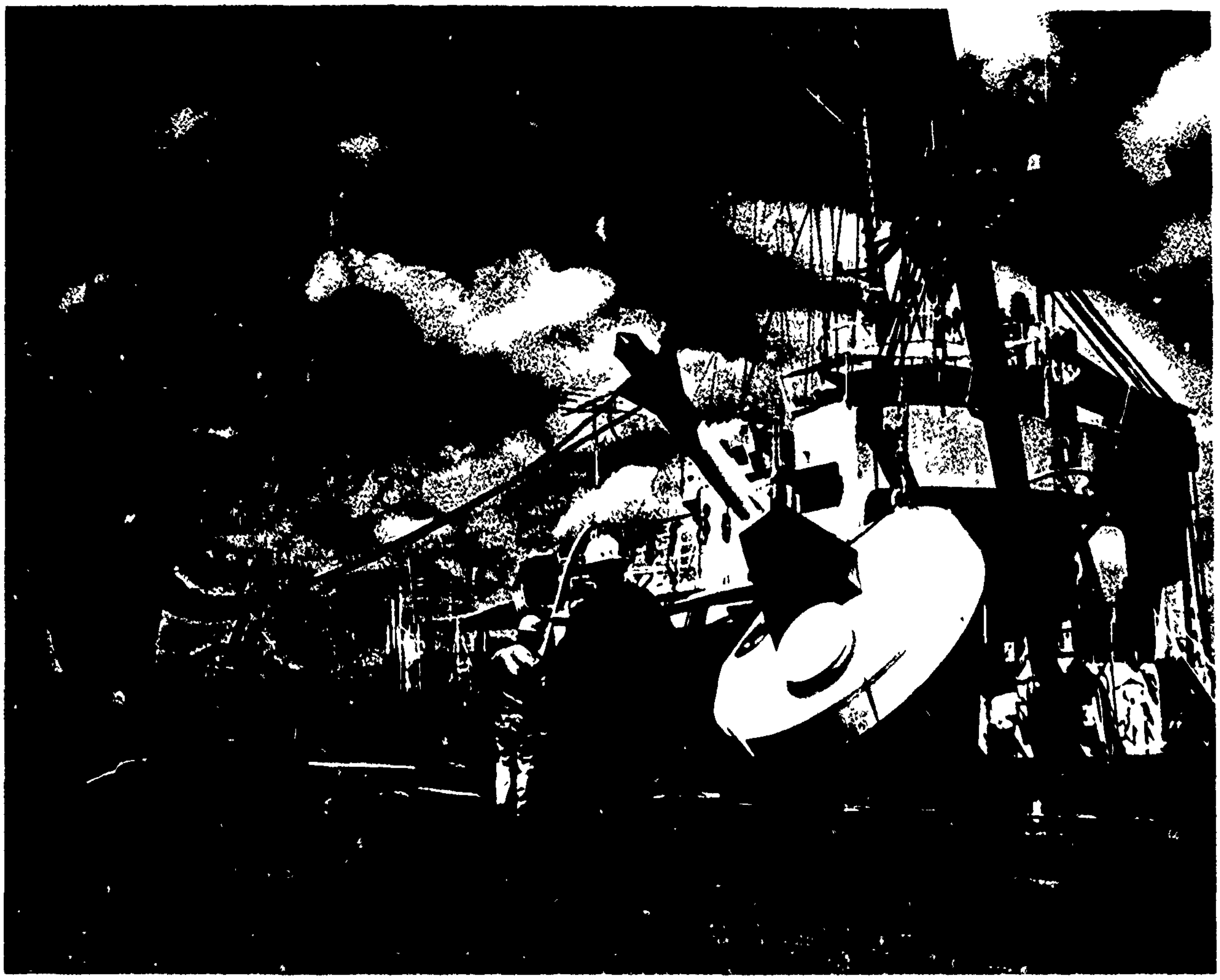
For the first time in history, the Great Lakes navigation season was extended to a full twelve months on the upper four Great Lakes. The tonnage passing through the Soo Locks for the FY 75 extended season (16 December - 31 March) was 9,134,539 tons, the largest total reached during the Demonstration Program. The large tonnage figure reflects the fact that the strike in the steel industry sharply curtailed the normal season shipment of ore which put a high demand on the need for shipping during the extended season to meet production needs.

Testing of ice buoys continued in confined waters of the Great Lakes and St. Lawrence River. RACON installations, as in past years, added significantly to safe vessel passages in difficult navigation areas. Field tests and demonstration of crew safety and survival devices focused heavily on individual and group exposure protection, distress alert and detection enhancement, and a man overboard alarm.

Tests of an ice boom designed to allow vessel transits were successfully completed at Copeland Cut in the St. Lawrence River. Model tests defined an optimum ice flushing system for the Eisenhower and Snell Locks. Measurements of ice forces on ice booms and piles were continued. An operational plan for the alleviation of temporary disruptions to ferry service in Little Rapids Cut in the St. Marys River was implemented. This included extensive efforts by the Coast Guard in the area of preventive icebreaking.

Improvements to the Lime Island airboat resulted in more satisfactory operation and improved passenger comfort. The bubbler-flusher system at Sugar Island performed satisfactorily throughout the extended season.

A model study of Little Rapids Cut in the St. Marys River identified a pair of ice booms as a poten-



*Experimental winter buoys are unloaded on St. Lawrence River*

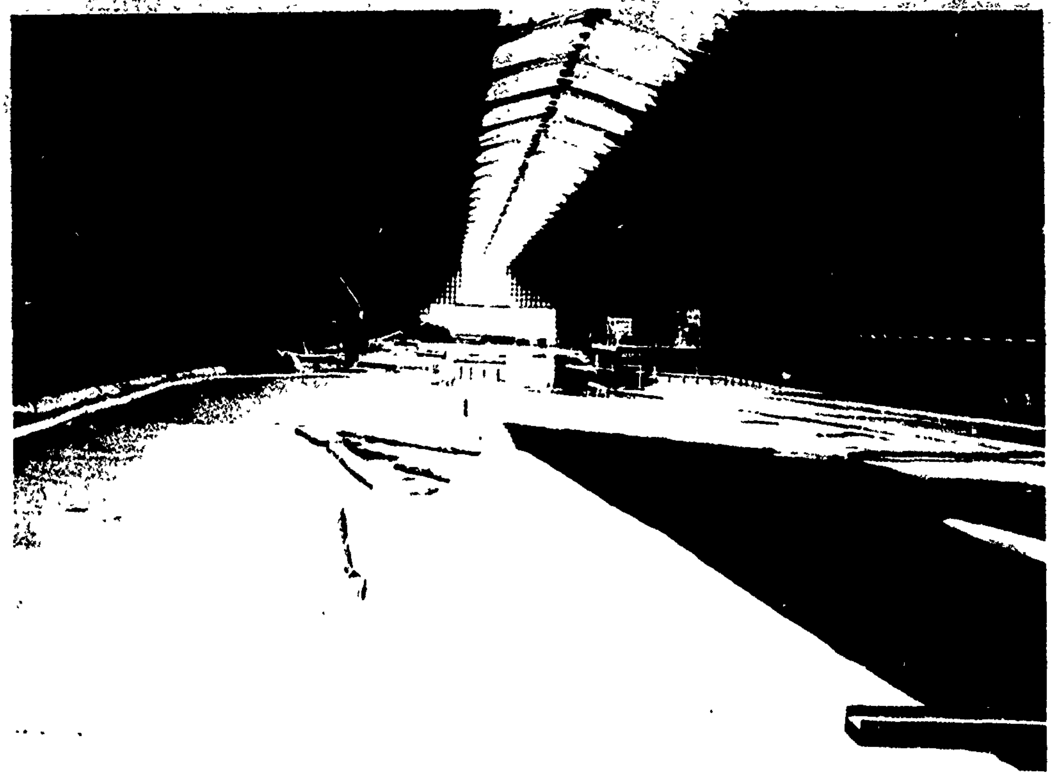
tially viable remedial measure to control ice floes in the Cut During the winter of 75-76, the thermal ice suppression test on Saginaw Bay was installed. In order to evaluate the potential impacts of the thermal ice suppression test, the collection of environmental baseline data in the area surrounding the test site location was continued The System Plan for All-Year Navigation (SPAN) on the St Lawrence River between Montreal and Lake Ontario was completed.

During FY 75, icebreaking operations were directed more to preventive or maintenance icebreaking than in previous years, placing greater emphasis on keeping the channel open rather than responding to requests for assistance This effort was particularly successful with ferry and ore boat traffic in the Little Rapids Cut area and in the St Marys River in general

Following the adoption of Long Range Navigation (Loran-C) as the national navigation system for the coastal confluence zone, the Coast Guard installed a mini Loran-C system in the St Marys River to test its effectiveness in an area of narrow channels.

The St Lawrence Seaway Development Corporation (SLSDC) contracted for the instrumentation and testing of an ice boom at Copeland Cut. The basic goal of the project was to collect data on the forces exerted on an ice control structure by water, wind, ice, and ships. An additional goal of the project was to physically demonstrate that a vessel could navigate through an opening in an ice boom without disrupting the stability of an ice cover or the hydraulic integrity of the river The data gained from the project has been used to calibrate mathematical and hydraulic model-

*View of St. Lawrence River ice model.*



ing techniques which would be used in future design optimization of other ice control structures in the St. Lawrence River

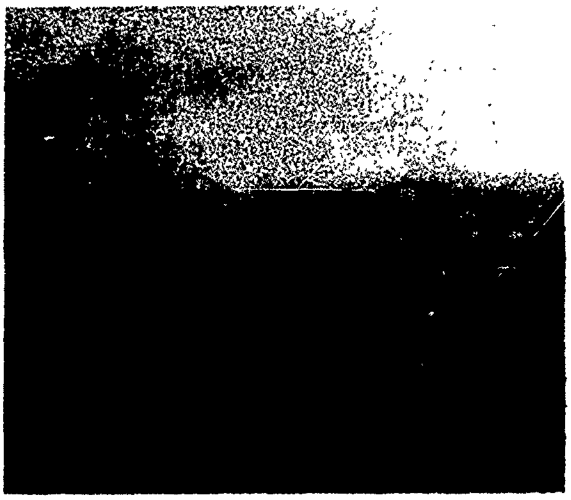
During the 1974-75 season, an operational plan was established for the St Marys River to deal with the island transportation problem. It operated in successive years, anticipating potential ice problems to the ferry service, and improving methods of coping with temporary ferry interruption The plan allowed for the complete termination of winter shipping should ferry service become seriously interrupted

A model study was conducted of the Little Rapids Cut area of the St Marys River in FY 75 As a result, a navigation ice control boom was installed to alleviate navigation-related ice problems The boom, reinstalled in each consecutive year, has been augmented with additional ice stabilization structures, and closely monitored with strain gauges.

Other activities included an outdoor recreation study on the St. Marys River, a fish study at a proposed long line bubbler site, pressure wave measurements, and a study of effects of turbulence on water sediments and organisms

*FY 76*

For the second consecutive year, the upper four Great Lakes operated on a twelve month basis. Tonnage of all cargoes passing through the Soo Locks in the St. Marys River reached 5.66 million tons, a decrease from the previous season, but in keeping with decreases in overall waterborne traffic throughout the world in 1975. The season on the St. Lawrence River ended on 20 December



*Ice near the Soo Locks.*

The bubbler/flusher system was again operated to assist the operation of the Sugar Island ferry. The Lime Island airboat was also tested this fiscal year. Further tests of electronic aids to navigation were performed, including RACONs, laser range lights, and precise laser/radar navigation systems. Initial tests were performed on the use of mini Loran-C in the St. Marys River.

Based on the results of the St. Marys River model study of the Little Rapids Cut, an ice boom with a navigation gap was installed above the Cut to provide a positive test of the ability of a boom with a navigation gap to retain ice when major vessels move through it.

A study was completed of the St. Clair-Detroit Rivers System to identify measures necessary to extend the season in that system. A four part study plan for environmental baseline collection and preliminary evaluation of the St. Lawrence River was initiated by SLSDC. The studies included fisheries, recreation, shoreline erosion and structure damage, and potential effects on island transportation.

In addition, the St. Lawrence River ice breakup forecast was completed and became operational in FY 76 and the Saginaw Bay thermal ice suppression system was tested.

*FY 77*

The winter of 1976-77 was particularly severe, causing the demonstration effort to close down during the month of February for an 11-month season on the upper four Great Lakes. Tonnage shipped through the Soo Locks totaled 2.94 million tons. Contributing to the low tonnage totals for that season was the fact that ore inventories in the industrial centers of the lower lakes were high, giving the shipping industry the option of halting movement because of adverse weather conditions.

Although the Demonstration Program was halted for a brief period, shipping through the Soo Locks continued throughout the winter at the request of the Canadian government to enable it to ship emergency cargoes of fuel oil.

The shipping season on the St. Lawrence River again was extended several days beyond the traditional closing date, but the severe conditions delayed the opening of the river three days beyond the April target date.

Funding constraints limited FY 77 demonstration activities primarily to ongoing activities, including icebreaking operations, operation of the Ice Navigation Center, ice and weather forecasts, operation of the St. Marys River ice boom, and those activities necessary to insure island transportation for the St. Marys River area.

Other activities conducted were modeling of the Galop Island ice boom modifications and a continuation of environmental studies on the St. Lawrence River by the Department of the Interior.

*FY 78*

For the third time, the Demonstration Program extended the navigation season to a full 12 months on the upper four Great Lakes. Tonnage shipped through the Soo Locks rose to 6.84 million tons. The shipping season on the St. Lawrence was extended to the latest closing date of the program (26 December 1977); however, the season opening was again delayed two days beyond the target opening date.

The majority of this year's activities centered around the St. Marys River. The ice boom was reinstalled above the Little Rapids Cut, along with additional ice stabilization measures, and was monitored throughout the season. The Lime Island airboat and Sugar Island bubbler/flusher were again tested and operated. A study was undertaken to determine effects of ship induced vibrations on shore structures. A limited shore erosion and dock damage protection study was undertaken.

A series of activities were undertaken to determine the effects of winter navigation in the area at the head of the St. Clair River, including a model study and field data collection. Environmental studies were continued on the St. Lawrence River and a study of macrobenthos was undertaken by the Department of the Interior in the St. Clair River.

The New York Department of Environmental Conservation (NYDEC) funded under the Demonstration Program conducted assessment studies to determine possible adverse effects of Demonstration Program activities on the St. Lawrence River.

*FY 79*

Again in FY 79, the final year of the Demonstration Program, the navigation season on the upper four Great Lakes was extended to a full 12 months. There were 536 transits through the Soo Locks during the extended season, carrying a total of 6.63 million tons of cargo. Shipping on the St. Lawrence River continued until 22 December 1978.

During this final year of the program the same operational activities (as done in previous years) were conducted to provide transportation to the Island residents including the ice boom, stabilization islands, Sugar Island bubbler/flusher, and the Lime Island airboat.

A number of environmental studies were conducted during this fiscal year. These studies included an analysis of control sites within and outside the proposed demonstration corridor on the St. Lawrence River, a comparative study of the St. Marys and St. Lawrence Rivers, a St. Lawrence River fisheries study, a study of ship-induced waves in an ice environment, and a study of the effects of winter navigation on waterfowl and raptorial birds in the St. Marys River area.

Again this year, intensive studies were performed to document ice conditions on the St. Marys River. These studies included vertical aerial and time-lapse photography, aerial reconnaissance, ice thickness measurements, and the continuation of shore erosion, shore structure damage, and hanging dam studies. Ice marking and monitoring and measurement of water levels and air and water temperatures were also conducted. The Great Lakes Environmental Research Laboratory continued its efforts with both short and long range freeze-up and break-up forecasts.

*A cold afternoon at sea.*

The National Weather Service installed additional equipment to receive weather satellite and Side Looking Airborne Radar reconnaissance imagery in an effort to improve the quality of ice forecasts and charts for Coast Guard and shipping operations.

A model study initiated in FY 78 was conducted in FY 79 of the St. Clair River to determine the optimum design of an ice control structure at the head of the St. Clair River. The study was supported by field data, including drogue studies to determine water velocities, measurement of under-ice water velocities, collection of additional weather data, and time-lapse photography of ice movement at the head of the St. Clair River.

Modifications to the Main Galop Island and Ogdensburg-Prescott ice booms to allow test transits

*Transit in the ice.*

of vessels were scheduled to take place in FY 79. These tests were indefinitely postponed because resolution of water levels and flow predictions from model studies could not be achieved and because environmental baseline data could not be obtained within the time limitations of the program authorization.

Opposition by private and governmental agencies of the State of New York was instrumental in focusing this lack of data. Additionally, the question of whether the State of New York, the International Joint Commission (IJC) or the Corps of Engineers had jurisdiction pertaining to the installation of booms, was not resolved.

Other studies conducted were: continuing tests of effectiveness of ice booms; the determination of forces on structures by both stable and moving ice; and demonstration of measures for dock structure protection.

The Coast Guard received the first in a new class of 140-foot icebreaking tugs which will replace some of the older vessels, greatly upgrading Great Lakes icebreaking capabilities.

## Part IV: Summary of Season Extension Results

The Demonstration Program activities were successful in substantially extending the season on the upper four Great Lakes during the entire program.

During the latter half of the program, the navigation season on the upper four Great Lakes was extended to a full twelve months. The closing date for the normal operating season for this system had been 16 December.

Over 41 million tons (approximately 4,000 vessel transits) of various cargoes were shipped through the St. Marys River during the extended season; more than half of this total was iron ore.

Much information was acquired on ice conditions throughout the system, and improved techniques were developed for collecting, disseminating and forecasting such information.

Traffic movement in the International Section of the St. Lawrence River above Montreal continued to 26 December, which was two weeks beyond the previously established closing date of 12 December. Ice boom improvements which will allow vessel movement through the booms have now been designed for this section of the River. Both physical and mathematical model studies have been conducted which indicate that minimal adverse effects will occur to the water level of Lake Ontario or flow of the St. Lawrence River. Because of time constraints, environmental and hydraulic questions could not be resolved, thereby precluding actual vessel transit tests in the area.

A significant portion of the resources for the Demonstration Program was used to investigate supporting systems for winter navigation season extension. The basic information collected from continued development of ice forecast techniques, data acquisition, surveillance of ice conditions, and special studies will be useful as a partial data base against which to compare future evaluations of the environmental effects associated with navigation season extension.

The findings and conclusions derrived from the Demonstration Program have been summarized in Part IV of the report beginning on page 129.

*Ice at a St. Lawrence River lock.*

# I. GREAT LAKES AND ST. LAWRENCE SEAWAY WINTER NAVIGATION: ITS BEGINNING

## The need

With the opening of the bi-national St. Lawrence Seaway in 1959, the Great Lakes-St. Lawrence Seaway became a navigable deep draft system, extending nearly half-way across the North American continent.

In the winter months, normally between mid-December and early April, the system is closed down by winter weather and ice conditions. The ports of the Lakes, among the largest in the Nation, with their giant gantries and their extensive cargo moving apparatus, are effectively closed and many of their people are without or seek other employment. Ocean vessels are excluded from the system and lakers head for winter mooring. Normal waterborne commerce all but stops.

The industrial heartland of America, which calls upon water transportation to provide its raw materials, reverts to more costly means of supply: the stockpiling of materials for continuing operation during the winter months or shipping by overland modes.

For many years and particularly since the opening of the Seaway, commercial shipping interests have considered the potential of an extension to the navigation season. Car ferries, in fact, do continue to operate year-round and, weather permitting, coal is moved from Toledo to Detroit and various petroleum products are moved in Lake Michigan and the Detroit area. However, other upper lakes navigation was forced to cease during the winter months--in part because of ice conditions--but also because it was not practical to handle frozen cargoes, especially iron ore. Then the development of taconite pellets in the late fifties to extend the waning supply of iron ore in Minnesota and Michigan made winter material handling operations feasible. This led directly to renewed interest in the possibility of extending the navigation season into the winter months.

The basic purpose of the Demonstration Program was to demonstrate the practicability of extended season navigation, utilizing for the most part, existing knowledge and current technology. An associated purpose was improving the state-of-the-art where existing technology was unable to cope with the problems.

## The system and the region it serves

The Great Lakes Basin, including the five Great Lakes -- Superior, Michigan, Huron, Erie and On-

tario -- comprises a land area of over 300,000 square miles drained by the St. Lawrence River through the Gulf of St. Lawrence into the Atlantic Ocean. Combining the St. Lawrence River, the basins of lakes and lakeway channels, the waterway encompasses some 95,000 square miles. The principal connecting channels in the system are the St. Marys River between Lakes Superior and Huron, the Straits of Mackinac between Lakes Michigan and Huron, the St. Clair River-Lake St. Clair-Detroit River system between Lakes Huron and Erie, and the Welland Canal between Lakes Erie and Ontario.

Navigation locks are located on three sections of the system: on the St. Lawrence River; on the Welland Canal; and on the St. Marys River (Soo Locks). The locks provide a lift of nearly 580 feet, between Montreal and the head of the Great Lakes. Lake vessels 1,000 feet long and 105 feet wide can traverse the largest of the five parallel locks at Sault Ste. Marie in the St. Marys River. Below Lake Erie vessel size is limited by lock dimensions to 730 feet in length and 76 feet in width. The channels and some 30 major harbors in the system have been improved through dredging to maintain a 27-foot controlling depth below low water datum.

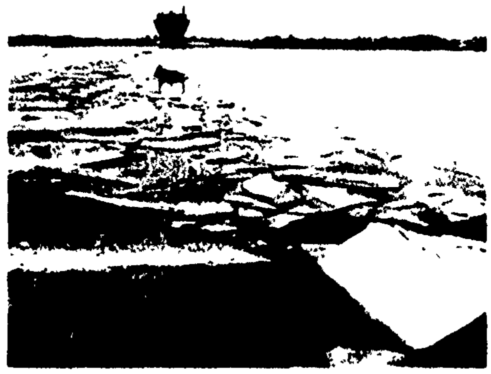
Depth over the sills of all locks in the St. Lawrence River and the Welland Canal is 30 feet. At the Soo Locks the depth for the MacArthur and Poe Locks are 31 and 32 feet, respectively, allowing transit of vessels drawing up to 25 feet 6 inches through the entire Great Lakes/St. Lawrence Seaway system.

The Great Lakes region is defined as consisting of a 19-state, economically identifiable tributary area including the eight states bordering the Lakes (Minnesota, Wisconsin, Illinois, Indiana, Michigan, Ohio, Pennsylvania and New York) and eleven adjacent states (Montana, Wyoming, Colorado, North Dakota, South Dakota, Nebraska, Kansas, Iowa, Missouri, Kentucky and West Virginia). This 19-state region generates 25% of the Nation's general cargo traffic and 16% of the bulk cargo, including midwestern grain shipments.

In 1977 the Great Lakes-St. Lawrence Seaway System carried 186 million tons of cargo, including significant percentages of U.S. waterborne traffic in iron ore (72%), coal (19%), limestone (76%) and gypsum (98%).

Two of the five largest U.S. cities with a population in excess of one million--Detroit and Chicago--are located on the Great Lakes. Based on 1970 figures, within the U.S. portion of the Great Lakes Basin area are some 30 million people -- more

*Vessel transiting the St. Marys River.*



*View of ice conditions over air bubbler.*

*Vessel passes marker in St. Marys River.*

*Coast Guardsman works in winter dress.*

*Crew works under winter conditions.*

than 14% of the total U.S. population. The Basin contains several national industrial centers and is oriented toward manufacturing. In fact, nearly four million people -- 35% of the business labor force -- are employed in manufacturing.

The Basin contains extensive mineral, forest, agricultural, and fish and wildlife resources. Nearly half of the Nation's steel production, 12% of its mining, and 37% of its grain emerge from the eight Great Lakes States alone. Also included within the Great Lakes Basin, of course, are heavily populated areas in the provinces of Ontario and Quebec, including the two largest cities in Canada--Toronto and Montreal.

## Congressional support

### *Prior studies*

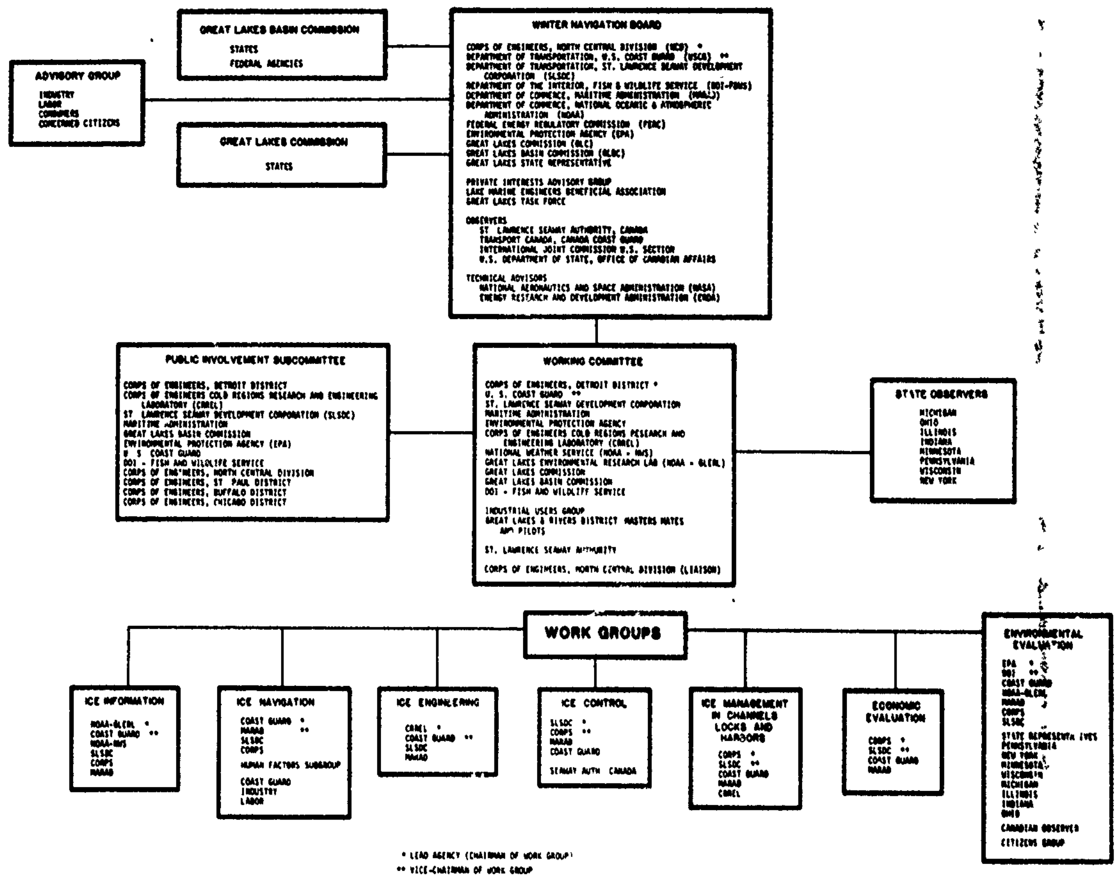
Prior to the authorization of the present Demonstration Program, Congress funded a conceptual study under *Sec. 304* of the 1965 River and Harbor Act *(PL 89-298).* The purpose of this study, entitled *Feasibility Report on Great Lakes and St. Lawrence Seaway Navigation Season Extension,* was to provide a preliminary report on the practicability, methods and economic justification for an extension of the navigation season on the Great Lakes-St. Lawrence Seaway System.

The study identified precise problems of winter navigation that currently preclude general intra-lake, inter-lake and international navigation. It included a review of world-wide techniques and experience, and identified the existing and potential physical and economic means which might be used to eliminate -- either partially or totally -- the problems associated with navigation under total ice conditions. The report recommended that a full scale study of the Great Lakes-St. Lawrence Seaway System be authorized in order to determine means of extending the navigation season, including (but not limited to) a determination of costs, economic justification and the environmental effects.

### *Current legislation*

The Winter Navigation Demonstration Program was authorized by Congress in Sec. 107 of the River and Harbor Act *(PL 91-611),* approved 31 December 1970. The Program authorization is composed of three

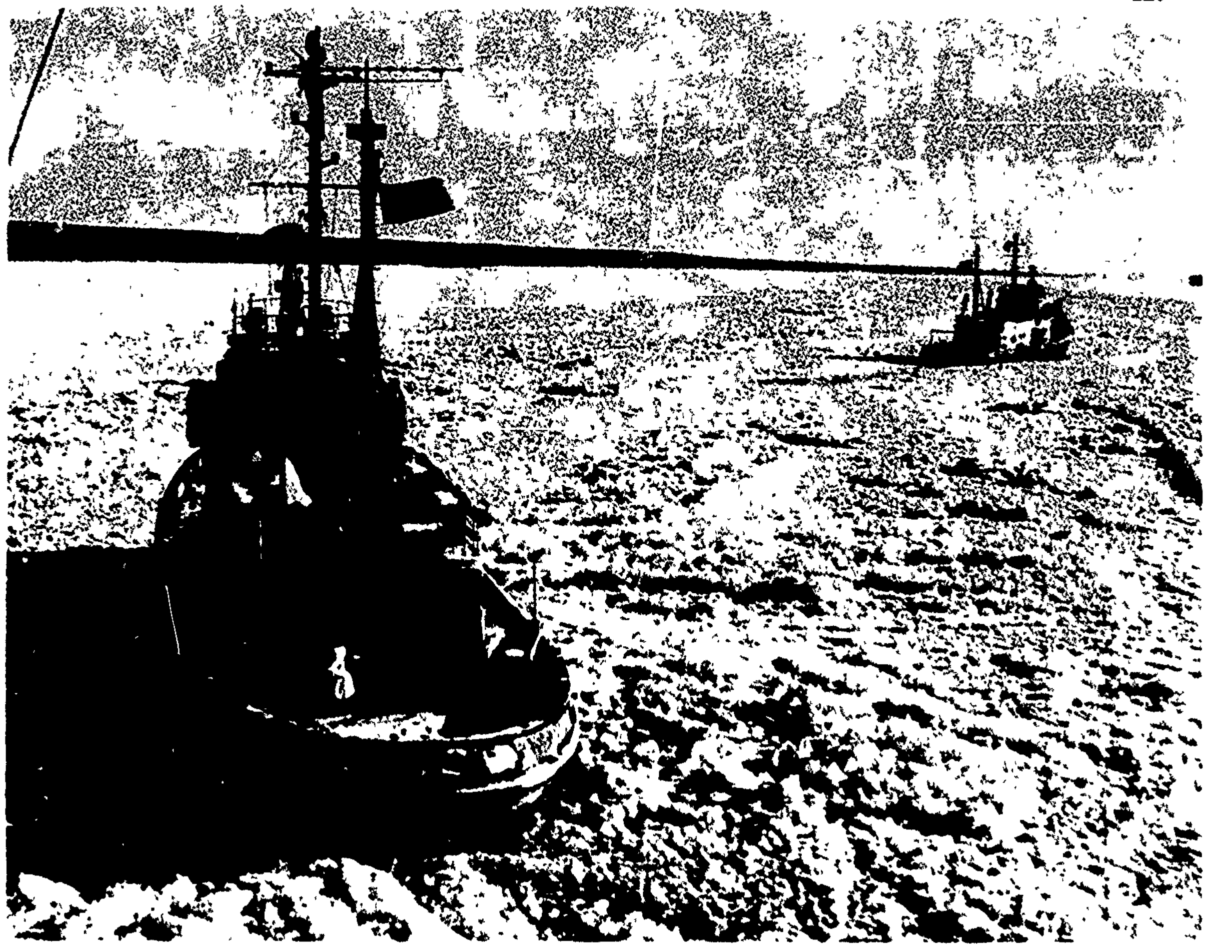
## ORGANIZATION CHART
## GREAT LAKES ST. LAWRENCE SEAWAY
## WINTER NAVIGATION BOARD




parts: (1) Section 107(a); a Survey Study to determine the economic justification, engineering practicability, and environmental and social impacts of an extended navigation season, (2) Section 107(b); the Demonstration Program, an action program aimed at demonstrating both the practicability and the means of extending the navigation season, and (3) Section 107(c), a study of ways and means to provide reasonable insurance rates for shippers and vessels engaged in waterborne commerce beyond the current navigation season.

Section 107(a): In partial response to the Survey Study authority an Interim Feasibility Study report dated March 1976 was prepared and recommended an extension of the shipping season to 31 January (± two weeks) on an operational basis for the upper four Great Lakes -- Superior, Michigan, Huron and Erie — and their connecting channels.

*Section 107(b)* of the Act stipulated that the results of the Demonstration Program should be submitted to Congress not later than 30 July 1974. However, *Section 70* of the Water Resources Develop-



*Coast Guard Cutter* Raritan *at work.*

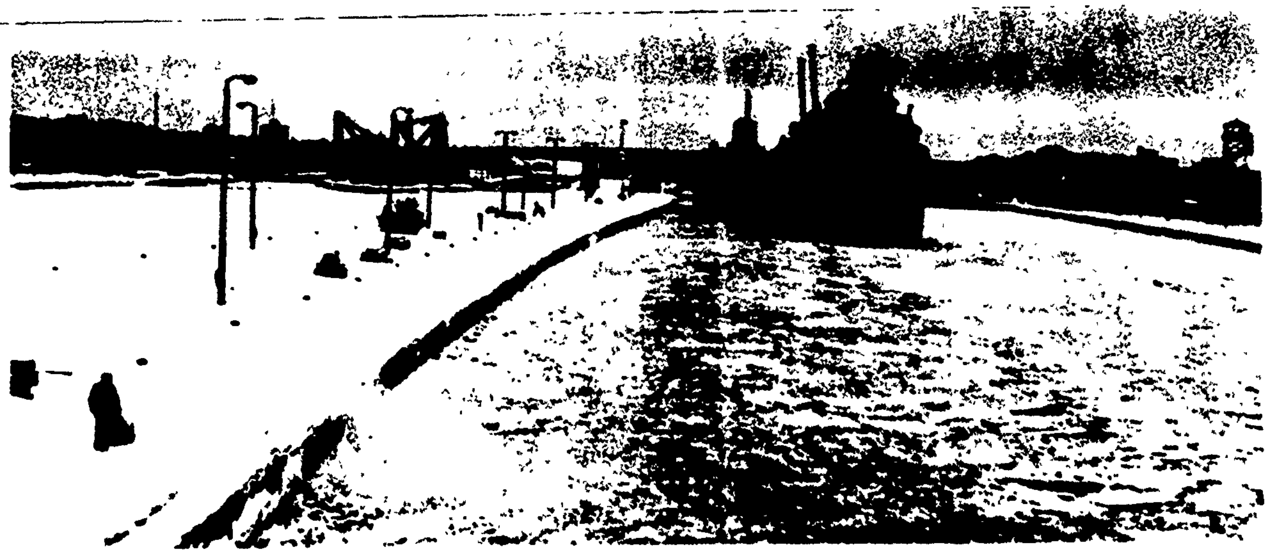
ment Act of 1974 *(PL 93-251)* amended the submittal date to 31 December 1976, and the Water Resources Development Act of 1976 *(PL 94-587)* further amended the submittal date to 30 September 1979 and increased the total funds for the program to $15,968,000.

Many key problems identified in the initial conceptual survey study are addressed in the Demonstration Program to determine if the problems can be physically overcome to permit winter navigation in the system. The Demonstration Program Final Report does not contain recommendations. Only findings and conclusions concerning the results of the extended season effort through FY 79 are included in the report. The Demonstration Program is a test of methods for winter navigation. It does not address feasibility of season extension, and ends in September 1979 with the submission to Congress of this Demonstration Program Final Report.

*Task management*

The Demonstration Program is organized under the broad terms of a Memorandum of Understanding signed at the headquarters level by the represented Federal Agencies. The complete memorandum is cited on page 135. The Winter Navigation Board is established under the memorandum to direct the multi-agency organization. The Winter Navigation Board is composed of senior representatives of the participating Federal agencies and invited non-Federal public and private interests to coordinate planning, programming, budgeting, execution and reporting or investigations and demonstration activities.

The agencies represented on the Board are the Corps of Engineers, Coast Guard, St. Lawrence Seaway Development Corporation, Department of the Interior, Maritime Administration, National Oceanic and Atmospheric Administration, Federal Energy Regulatory Commission, Environmental Protection Agency, Great Lakes Commission, and Great Lakes Basin Commission. An Advisory Group to the Board, formed to provide input from industry and labor, provides two members to serve on the Board. Additionally a representative of the eight Great Lakes states is a member of the Board. Observers from the St. Lawrence Seaway Authority of Canada, the Canadian Coast Guard, the International Joint Commission and the U.S. Department of State are also included in the



*Vessel at Soo Locks.*

Board structure, as well as technical advisors representing the U.S. National Aeronautics and Space Administration and the Energy Research and Development Administration.

The Division Engineer, North Central Division, Corps of Engineers, serves as Chairman of the Winter Navigation Board; the Coast Guard Commandant, 9th Coast Guard District, is vice-chairman.

A Working Committee, similarly constituted as the Board, directs seven Work Groups which carry out the program activities approved by the Board. The Working Committee provides continuous coordination of program activities and develops and coordinates plans, programs, budgets, schedules, work descriptions, and reports for consideration by the Board. The District Engineer, Detroit District, Corps of Engineers, serves as Chairman of the Working Committee.

The investigation and demonstration activities were divided among the seven program elements (Work Groups) with a Federal agency designated as lead agency for each. Each work group is listed with a brief statement of its objective.

Ice Information (National Oceanic and Atmospheric Administration); Activities involved documenting ice-cover formation, movement, and decay; collection of operational data on ice and weather conditions, and the development of short- and long-range forecasts of ice conditions.

Ice Navigation (U.S. Coast Guard); To provide safe and efficient movement of vessels through ice-covered waters.

Ice Engineering (U.S. Army Corps of Engineers); To assess and advance the state-of-the-art in ice mechanics and engineering as required for winter navigation on the Great Lakes-St. Lawrence Seaway System, to develop adequate instrumentation and measurement techniques, and to develop design criteria for structures to withstand ice forces.

Ice Control (St. Lawrence Seaway Development Corporation); To demonstrate the feasibility of winter navigation on the St. Lawrence River.

Ice Management in Channels, Locks and Harbors (U.S. Army Corps of Engineers); To develop and implement techniques, operating procedures, and ice control devices for effective and efficient vessel operation during the winter navigation season.

Economic Evaluation (U.S. Army Corps of Engineers); To define items having economic feasibility for winter navigation on the Great Lakes and St. Lawrence Seaway.

Environmental Evaluation (Environmental Protection Agency); Evaluation of environmental effects of specific demonstration projects that involved physical contact or interaction with the environment. Provide supervision and guidance on the data needs, methods of evaluation, and preparation of the environmental assessments.

Each lead agency was responsible for carrying out its element of the program utilizing its own manpower, but with support from other Government agencies and outside contracts, as necessary.

The organization also included a Human Factors Subgroup within the Ice Navigation Work Group, and representatives of the eight Great Lakes states and the Sierra Club within the Environmental Evaluation Work Group.

A State Observers Group represents individual states and provides liaison between the eight bordering Great Lakes states and the Working Committee. The observers report back to their states on the activities of the Demonstration Program and also report their state's interests to the Working Committee.

A Public Involvement Subcommittee of the Working Committee is composed of members of the various concerned government agencies, and was formed to keep the public advised of Demonstration Program activities. Contact with news media, the publishing of information bulletins, and the conducting of seminars are among the activities of the subcommittee.

A Legal Committee consists of representatives from the Corps of Engineers, St. Lawrence Seaway Development Corporation, Power Authority of the State of New York, and the Toledo-Lucas County Port Authority. The purpose of this Committee is to identify the legal questions and responsibilities related to an extension of navigation season into the winter months.

The program elements of the work groups fall into two primary areas: The Ice Information, Ice Navigation, Ice Engineering, Ice Control and Ice Management work groups comprise the action program dealing with the demonstration of the extended season's practicability within their designated areas of responsibility. The Economic Evaluation and Environmental Evaluation Work Groups are responsible for analyzing the environmental effects and economic costs of specific demonstration activities.

### *The Demonstration Program Final Report*

This report is divided into five main sections as follows:

1) The Winter Navigation Board Summary Report which contains a broad overview of the entire Demonstration Program.

2) Part I, a general review of the background of the program and the organization of the Demonstration Program effort.

3) Part II; a description of the problems faced in an extended navigation season.

4) Part III; a discussion of the activities undertaken during the Demonstration Program together with the corresponding results.

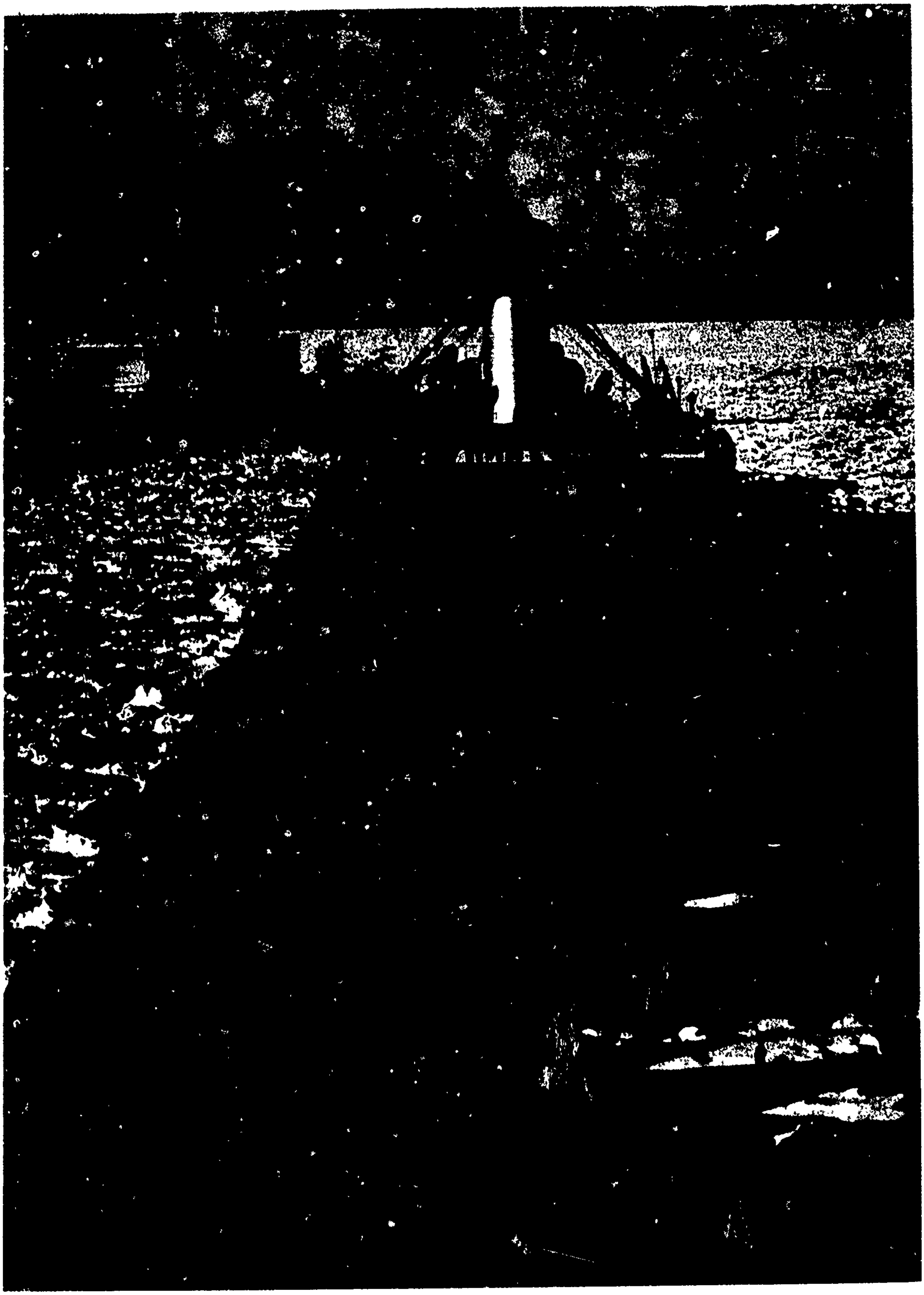
5) Part IV; an overview of the conclusion that can be drawn from the Demonstration Program activities.

## Other reports

The activities, findings and conclusions during the first five years of the Demonstration Program, as indicated previously, have been described in four annual reports and a Demonstration Program Report prepared at the end of FY 76. Other reports dealing with key controversial issues have been prepared including the following.

A report, "Legal Considerations Associated with an Extension of the Navigation Season on the Great Lakes and St. Lawrence Seaway," was prepared by the Legal Committee. The Legal Committee was established to consider the problems that may result from activities conducted by the Winter Navigation Board and interested federal agencies to extend the navigation season. The areas of potential impact which were considered included damage incidental to navigation such as damage to locks, harbor facilities, and vessels. Other types of damage primarily ice related, included ice scouring of the shoreline, damage to shoreline structures, ice clogging of water intakes and sewage outfalls, and reduction of flows at powerhouses due to ice jams. While these types of damages may occur naturally it is felt by some that they may occur with greater frequency and potentially greater severity during an extended season with its associated ship movement in ice. The Legal Committee also advised the Winter Navigation Board as to the rights and liabilities of the United States with respect to an extended navigation season. The conclusions reached by the Legal Committee have been incorporated into the Survey Study.

A three-volume report, "Environmental Assessment: FY 79 Winter Navigation Demonstration on the St. Lawrence River," funded under the Demonstration Program, was prepared by the New York State Department of Environmental Conservation in cooperation with the State University of New York College, New York College of Environmental Science and Forestry. This environmental assessment suggested possible adverse environmental impacts of the proposed FY 79 Demonstration Program to the St. Lawrence River, and its terrestrial riverine ecosystems in relation to physical, biological and cultural resources. It was the explicit basis of the Commissioner of the New York Department of Environmental Conservation in concluding the risks of a Demonstration Program were too great without extensive and systemwide environmental studies being accomplished beforehand.



*Icebreaker runs interference.*

# II. OBSTACLES

This section contains a brief overview of the problems encountered with the extension of the navigation season on the Great Lakes-St. Lawrence Seaway. It is followed by a section discussing the activities undertaken to show these problems can be engineeringly overcome. Also in that section is a discussion of the results of those activities.

## Nature and ice

*General climate conditions*

The Great Lakes lie between latitude 41°21′ N and 49°00′ N and longitude 76°04′ W and 92°06′ W, at the confluence of major storm tracks that cross the North American continent. Because of the immense size of the Basin, a wide variety of weather conditions can exist at the same time.

The water volume (5,500 cubic miles) and surface area (95,000 sq. miles) of the Great Lakes act both to influence temperatures and function as a reservoir for the storage and exchange of heat energy with the atmosphere.

Average annual temperatures range from 39.0° F on Lake Superior to 48.7° F on Lake Erie, with minimum monthly temperatures generally occurring in January and February.

Precipitation in the form of rain, snow, and condensation is the source of water for the Great Lakes. The mean annual precipitation (1900 - 1978) for Lake Superior, Lake Michigan, Lake Huron, Lake Erie, and Lake Ontario basins are 29.7, 31.4, 31.4, 34.0, and 34.6 inches, respectively. The number of days having measurable precipitation ranges from an average of 169 days east of Lake Ontario and 155 days along the southern shore of Lake Superior to 119 days at the southern end of Lake Michigan.

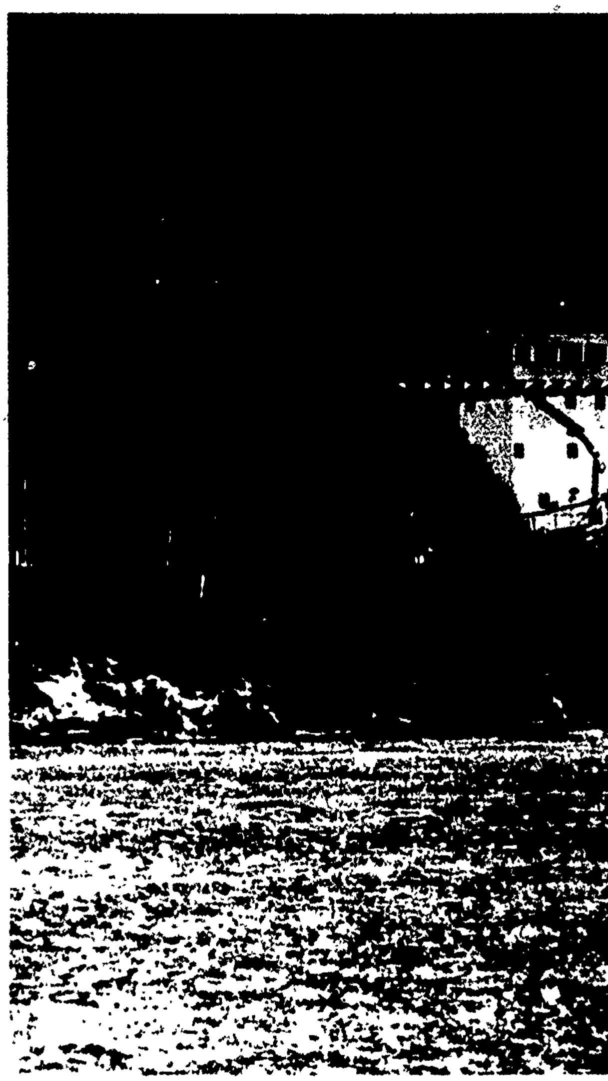
*Winter climate*

The range of winter temperatures across the Great Lakes Basin can be seen by comparing the January monthly mean temperatures at Cleveland and Duluth: for the former, on the south shore of Lake Erie, 27.5° F and at Duluth 8.8° F, a difference of more than 18° F. These wide differences in temperature also account for variations both in severity and in the length of the winter season which, in turn, determines the extent of the ice cover on the Lakes.

The moderating effect of the Lakes on the temperature regime is pronounced during the winter, when mean lake temperatures may be as much as 30° F warmer than mean air temperatures. This differential results in high rates of evaporation which, when carried over land, creates heavy snowfall downwind of each of the Lakes. This effect is reduced, of course, when lake shores have become ice covered.

Seasonal snowfall in the region varies greatly from year to year, with annual snowfalls of less than 20 inches to the south of the lower Lakes, while annual snowfalls exceed 140 inches east and south of Lake Superior and east of Lake Ontario. Elevated areas east of Lake Erie can experience more than 100 inches during a normal winter. The St. Lawrence River area has an average snowfall of 80 inches.

*The* Leon Simard *at Thunder Bay oil dock.*



*Generalized ice conditions found in the Great Lakes-Seaway System*

A simple sequence of ice formation rarely occurs on the Lakes because of the variable weather conditions that prevail during the winter months. Extremely low air temperatures may occur for a number of days allowing an extensive, but thin, ice cover to form. The cold spell may be followed by warm weather and strong winds, and consequently the thin ice cover is broken up and concentrated on a lee shore or melted in the lake by upwelling warm water. The effects of winds, currents, and upwelling upon the ice cover causes its areal extent and distribution to change rapidly. Large lake-surface areas also influence the ice cover by causing it to react to water level fluctuations. Water level changes tend to keep the ice in a fluid state and make it more susceptible to wind and current action It can be seen that ice cover on the Great Lakes is affected by many hydro-meterological factors, but each lake has its own characteristics that affect ice formation and distribution.

Many physical and environmental problem areas associated with winter navigation on the Great Lakes-St. Lawrence Seaway System involve four principal water navigation areas: (1) navigation channels, both interlake and on the St. Lawrence River, (2) harbors, (3) locks, and (4) open lake courses. They are affected by a wide variety of icing conditions. Ice in the connecting channels and river channels severely limits vessel movements, especially at channel bends in constricted areas and where ice booms have been installed.

## Moving through the ice

*Ice cover in lakes and harbors*

To move ships through the solid ice cover in lakes and harbors requires icebreaking assistance. The development of a means of retarding or suppressing ice formation would also ease the movement of ships. To some extent, shifting ice cover and wind-blown ice occur on all the Lakes. Drifting ice forms into large ice fields that shift with winds and currents. Icebreaker assistance is often required to maintain vessel tracks through this ice, primarily on Lakes Superior, Michigan and Huron, and at Lake Ontario's eastern end.

Lake Erie, the shallowest of the Lakes, may freeze over completely, and wind conditions can often shift ice over the vessel tracks Large ice fields on the open Lakes are capable of trapping vessels and physically carrying them out of shipping lanes, possibly even running them aground.

In the shallower bays and straits of the more northern Lakes, where drifting ice is also prominent, high winds may pile ice into windrows and pressure ridges 10 to 20 feet above the water and 30 to 35 feet below, often anchored to the lake bottom. Windrows create difficulty to navigation specifically at the entrance to the Duluth-Superior Harbor at the western end of Lake Superior, Whitefish Bay and the upper St Marys River at the foot of Lake Superior, the island areas of northern Lake Michigan, the Straits of Mackinac and the extreme eastern end of Lake Erie.

Ice floes and fields may be pushed by winds into harbor areas, occasionally halting vessel movement within harbors or through the entrances. Shifting or lessening wind intensity normally allows the floes or fields to drift back into the lake.

*Ice conditions in the rivers*

Where stable ice is disturbed by vessel movement or by winds and thaw conditions, the loose ice can move downstream and jam in constricted areas. Ice jams cause upstream levels to rise, and provide a flood threat to low lying areas. This happens frequently in the St. Marys, St. Clair, Detroit and St. Lawrence Rivers under natural conditions, regardless of ship movement.

Ice jams can also retard the normal flow of water, reducing the amount available for downstream power production, and can hamper ferry operations, increase shore erosion and structural damage.

Because the lengths of many vessels range between 600 and 1,000 feet, ice cover in the vicinity of tight turns or narrow channels tends to reduce the turning and maneuvering capabilities of the vessels. As a result, Coast Guard icebreakers are frequently required to work alongside a vessel to reduce friction resistance or to widen a turning area.

Power entities install ice booms to help establish and maintain stable ice covers, reduce the potential for ice jams and insure a steady current flow through intake gates. Ice booms are traditionally placed in the Niagara and St. Lawrence Rivers each winter. In the International portion of the St. Lawrence River, two booms extend across the navigation channel and remain there until just before spring navigation in late March.

*Other ice conditions*

As ice deteriorates and is broken up by winds, waves and pressure, it forms slush ice, one of the most difficult forms of ice to combat. Slush ice can close in around a vessel, preventing movement in any direction. It can damage propellers and steering gear, clog condenser intakes and exert pressure on the hulls of trapped vessels. This is a particular problem during spr g break-up in Lake Erie, because the current and prevailing winds pack the slush ice into a shallow bottleneck in the eastern end of the Lake.

## Traffic control

Traffic control on the St. Lawrence River from Montreal through Lake Ontario and the Welland Canal to Lake Erie is accomplished using a joint system managed by the St. Lawrence Seaway Development Corporation and the St. Lawrence Seaway Authority of Canada. The system, which is premised on making the most efficient use of the Seaway locks, is a finite traffic control system which requires vessels to make radio calls establishing their positions at regular intervals. Vessels are tracked on an incremental basis, with the position of each vessel recorded as it passes designated calling-in-points. The calling-in-points are located approximately one hour's sailing apart, under normal conditions and gives control operators complete information for any needed control of traffic flows and patterns. Additionally, this system provides vessel pilots and masters with a total scope picture of traffic, thus improving the safety and efficiency of transits.

A first-come, first-served policy functions at the Soo Locks, with downbound and upbound vessels alternating through the locks. During winter operations at the Soo, however, the lockage of large ore carriers can result in lengthy delays to other ships. This is due, among other things, to the build-up of ice on lock walls as a result of the size of the vessels.

This problem has given rise to consideration of a lockage policy other than a first-come, first-served basis in order to more efficiently expedite shipping. The lockage of smaller ships (less than 105 feet wide) before the larger vessels, provided they are part of the same convoy, would keep shipping moving more rapidly without the problem of the ice coating of lock walls. Other considerations that remain critical to such a judgement include the horsepower of the smaller ships, locking experience with wide ships, existing ice conditions, available ice tracks and an ability to pass. The basic policy of first-come, first-served in such cases would continue except where delays would be predictable

*Winter along the St. Lawrence Seaway.*

An extended navigation season will require precise traffic control on the upper lakes to assure the safety of participating vessels, particularly in the channel areas.

Navigation in narrow channels requires extra caution particularly in those areas similar to the Middle Neebish Channel in the St. Marys River and the Livingston Channel in the lower Detroit River. These areas normally handle one-way traffic, but for an extended season they are required to handle traffic from both directions. New traffic regulations and a vessel traffic center may be required to expedite this kind of vessel movement.

Except on the Montreal to Lake Erie portion of the System there is currently no reliable method of determining if a vessel has been lost or damaged (aside from distress signals) until the vessel is overdue at its destination or until it has failed to file a routine report to its owner. Since the crew survival time is dramatically reduced during winter operations, an adequate vessel reporting system must be developed to help ensure vessel and crew safety.

To make a more efficient use of the Coast Guard's icebreaking fleet, a system needs to be developed to monitor proposed ship voyages and, where possible, form them into convoys.

### *Vessel speed enforcement*

Speed regulations are the responsibility of the U.S. Coast Guard and the St. Lawrence Seaway Development Corporation. These regulations are found in Title 33 Code of Federal Regulations (CFR) 92.49 (St. Marys River), 33 CFR 162.135 (Detroit-St. Clair Rivers), and 33 CFR 401.28 (St. Lawrence River).

Vessel speeds are monitored using Doppler radar or by measuring the time a vessel travels its own length. During the regular navigation season, vessel speeds are checked at random times of the day or night. During winter navigation, the level of speed monitoring is reduced commensurate with vessel traffic levels. Civil penalties are assessed for significant violations.

Excessive speed by vessels under both summer and winter conditions can increase shoreline erosion and damage to property. A program is underway to monitor vessel speeds, shoreline erosion and reports of property damage during winter sailings, to determine if speed limits need adjusting.

## Staying in the channels

*Navigational requirements*

In the open waters and the larger bays of the Great Lakes, a ship's navigator requires all-weather aids to navigation to determine his position and to assist him in a safe transit.

Traditionally, in Great Lakes harbors and connecting channels, all lighted buoys and radar reflector-equipped unlighted buoys are withdrawn during late November or early December to prevent damage and/or loss of the aid during winter months. Some of these more sophisticated aids to navigation are replaced with unlighted buoys without radar reflector equipment. Such winter markers are barely adequate, representing a significant reduction in overall effectiveness.

In addition, the buoys are subject to submersion or movement off station by ice. Because of the obviously questionable reliability of floating aids used to mark channels during the winter navigation season, vessel personnel are often uncertain as to their vessel's exact position within a channel.

*Navigational hazards*

Navigational hazards are also present during cold and stormy weather conditions when fog, low clouds, rain or blowing snow reduce visibility. In narrow connecting channels, ranges and similar aids are difficult to locate and radar, as now employed, is not sufficiently accurate.

Improved forms of navigation aids will be required for safe and efficient movement of vessels during the winter season. The establishment, for instance, of Loran-C in the Great Lakes will have an important influence on navigational accuracy. This all-weather system should be operational by 1980, enhancing present systems of coast lights, radio beacons, and fog signals. More precise navigation systems are required for the rivers and channels.

## Information to aid navigation

Weather and surface conditions found on the Great Lakes and their connecting channels differ markedly from those encountered during the bulk of the traditional shipping season. Winter storms historically can be severe on the Great Lakes (even though some of the most severe storms are in November and April). The harsh weather conditions during winter increase the difficulty of even simple tasks.

As previously discussed, ice cover causes varying problems throughout the Great Lakes-St. Lawrence Seaway System. To ease the impacts of these factors it is necessary to develop a comprehensive system of data collection for use by vessel operators and to provide a basis for predicting in advance adverse conditions so they may be avoided or prepared for. Coupled with this, an organization is needed to digest the data and take responsibility for getting the information and forecast to shipping personnel who require it.

The National Weather Service (NWS) has been disseminating weather forecasts and warnings to the Great Lakes shipping industry since 1870, and ice information since 1897. Extension of the navigation season to 12 months has required an increase of about 30 percent in the effort expended to make weather forecasts and an increase of several thousand percent in the effort devoted to ice forecasting. Most of the techniques and communication channels used are logical extensions and developments from those long used for the traditional navigation season. Loss of the "closed season" has removed the traditional wintertime respite which was used to review, reconsider, adjust, repair, and recoup. Needed changes can no longer be delayed until the end of the season, and are more likely to cause a noticeable interruption in the services.

## Problems of winter navigation

*Potential vessel damage*

Some of the vessels currently operating in ice conditions have not been specifically designed for that purpose. Therefore, the potential for vessel casualties due to ice exists and is likely to increase as traffic increases. Regulations for the strengthening of hulls, reduction gears, rudder stocks and propellers may be required in the future. At present, several high-powered vessels

*Vessels pass in ice at Whitefish Bay.*

which routinely operate in ice as a result of the extended season have received some hull strengthening.

*Refuge area access difficulties*

In sudden storm conditions, heavy ice fields have been identified as potential obstructions to the quick and timely access of vessels to refuge areas. At the same time, however, such ice fields have a dampening effect on open waters and significantly lessen wind, current and wave action. This partially negates the potential damage which could arise from restricting access. The ice fields themselves become something of a refuge area.

*Adverse search and rescue conditions*

In open water areas, winter storm conditions can create both limited visibility and heavy seas, hampering rescue operations. The Coast Guard has had worldwide experience in search and rescue operations encompassing all types of weather and is well equiped to meet most navigation responses.

*Hazards to lock and dock personnel*

The extended navigation season creates problems for people working outside, especially at locks and on harbor docks, where extreme weather conditions can cause frostbite or hypothermia. Appropriate clothing and safety gear are obviously required.

Ice buildup on the sides of vessels moving along piers will sometimes shear off and shatter over work and walk areas causing potential personnel hazards. In addition, wind-blown snow frequently overhangs pier edges, obscuring them and causing a hazard for those who have occasion to walk to that edge. Ice on piers and heavy winds also cause problems with solid footing.

Hazards at locks are apparent in the removing of ice collars. Steam is used when it is available. Other more common methods include use of a back hoe, chipping with a bucket or modified ripper, or with a tractor-operated ice cutting chain saw. All of these methods of ice collar removal present hazards.

At times it is difficult and time consuming to close lock gates during winter navigation. This fact creates a potential problem should an injured person have to be brought across the lock to receive treatment.

*Hazards to vessel crews*

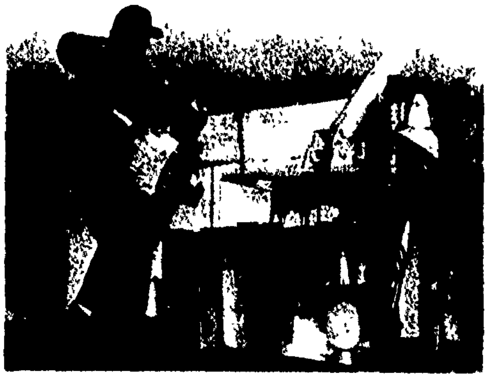
Vessel crews encounter many of the same hazards as those experienced by lock and dock personnel. Ice and snow can create dangerous footing situations on deck surfaces. Also wind and cold conditions may require special clothing for crew comfort and protection.

Additional hazards to vessel crews are encountered in cases of man overboard or an abandon ship situation. In such instances, the survival of personnel during immersion in water is dependent not only upon the victim overcoming the immediate danger of drowning, but upon individual reactions to stress associated with heat loss and thermofailure.

Immersion in water rapidly increases the victim's heat loss due to the decrease in the thermal insulation of his clothing. While common personal floatation devices and life rings enable a survivor to remain afloat, they are of no use in providing thermal protection or protection from wave action and spray.

Life boats and rafts are more effective in these situations because they remove the victim from the water and its effects. However, life boats have problems associated with both launching and boarding in rough seas, and they lack adequate maneuverability They also fail to provide adequate protection from wave spray.

*Crew works in winter dress.*



*Coast Guardsmen set up lights to permit icebreaker to work at night.*

*Navigational aids have been pulled for the winter from constricted channels.*

Mackinaw *works around the clock to free lake carriers.*

Additionally, the cooling of a victim's extremeties may impair his manual dexterity, making it difficult to grasp a life ring or a thrown line. Stress due to cold may also cause coronary occlusions or similar fatalities.

Because research indicates that seamen who fall overboard in winter and spend any time at all in the water are seldom recovered alive, a system to detect these accidents as they occur as well as adequate locating and recovery techniques are critical to the winter navigation effort.

Better designed life craft are also needed in cases where vessel personnel will have time to abandon ship using the life craft. Crews should also be provided routinely with equipment or clothing that provides adequate floatation and thermal protection.

*Vessel master/pilot training assessment*

As a result of ice conditions, navigation poses difficulties both for vessel masters and pilots. Some masters and pilots have not had a great deal of experience operating under ice conditions. This requires a certain amount of training and experience.

*Removal of wrecked or stranded vessels*

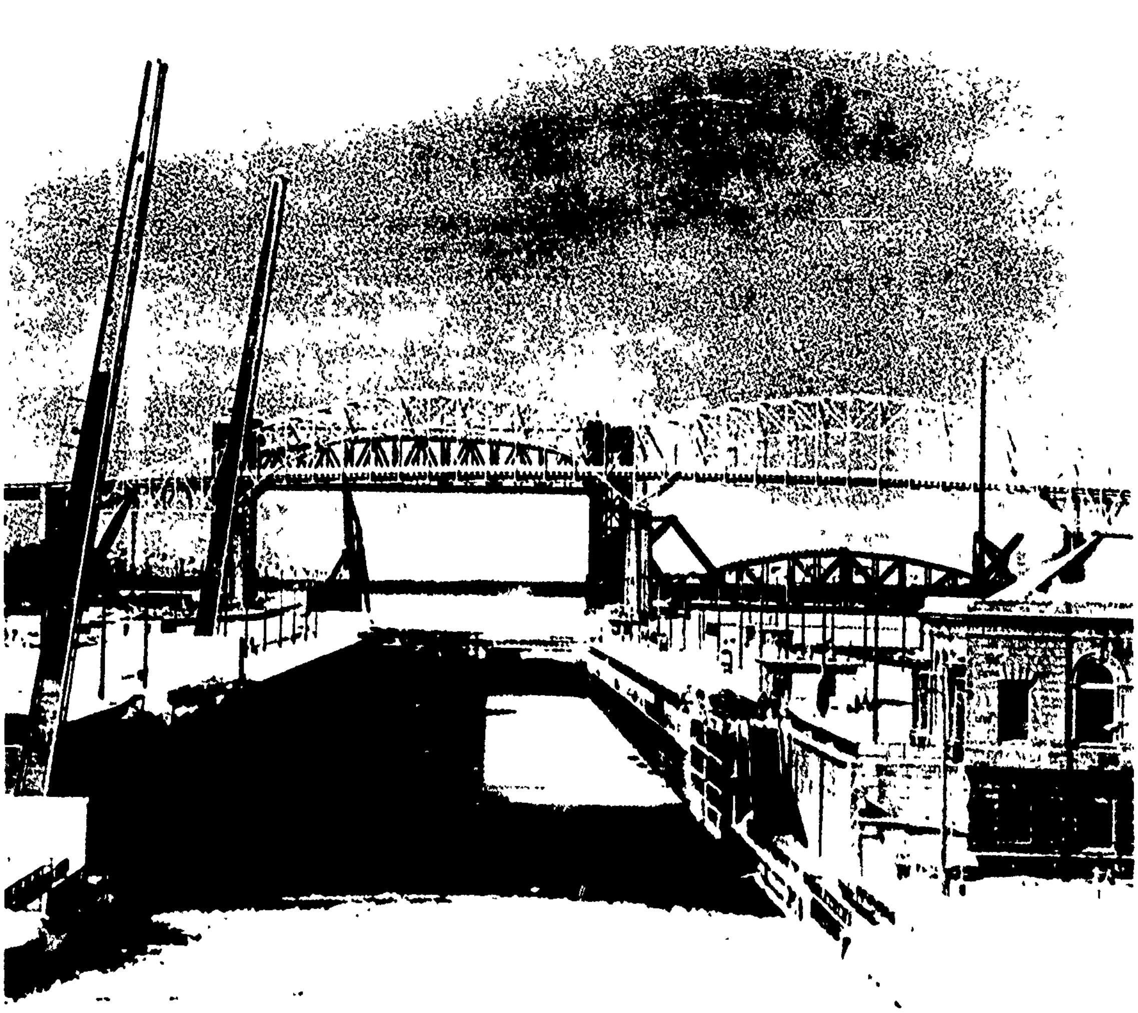
Owners of a stranded vessel generally take prompt action to free it because of the value of the vessel and its cargo. Most stranded vessels are expeditiously removed by owners with the assistance of commercial tugs or lighters. If a stranded vessel is an obstruction to navigation, the owners are required by law to clear the channel as quickly as possible.

During the winter months such a situation is compounded considerably, due to the general inability to control a vessel in heavy ice conditions, particularly in turns between courses and in areas where ice tends to windrow. Other problems occur in open lake situations where large ice fields can trap a vessel and the ice drifts with the wind and current, forcing the vessel aground.

These situations are difficult to anticipate and predict. Each casualty is unique. What may appear to be a relatively simple grounding might result in holing and the subsequent flooding of vessel compartments. When lightering is required, further problems are created in getting a second vessel or a lighter alongside the crippled vessel to accept part of the cargo.

In the extreme case of a vessel sinking in a navigational channel during the winter months, the remedy to the problem becomes much more time consuming and costly. Oil pollution could also delay salvage operations (U.S. Coast Guard is responsible for cleaning up spills).

Should a serious accident occur in certain critical areas of the channel, it might be necessary to suspend navigation through the area until the obstruction can be cleared.



*Lock icing at Soo Locks.*

**Special problems of the rivers**

*International*

The water levels of the Great Lakes are a result of an integration of the hydrologic factors which affect both land and lake surfaces of the Basin as well as the hydraulic characteristics of the connecting channels and the St. Lawrence River. These levels are the characteristic which most frequently affect man's use of these waters, since they control shoreline use and navigation and influence the amount of hydro-electric power which can be produced in the connecting channels and the outlet river.

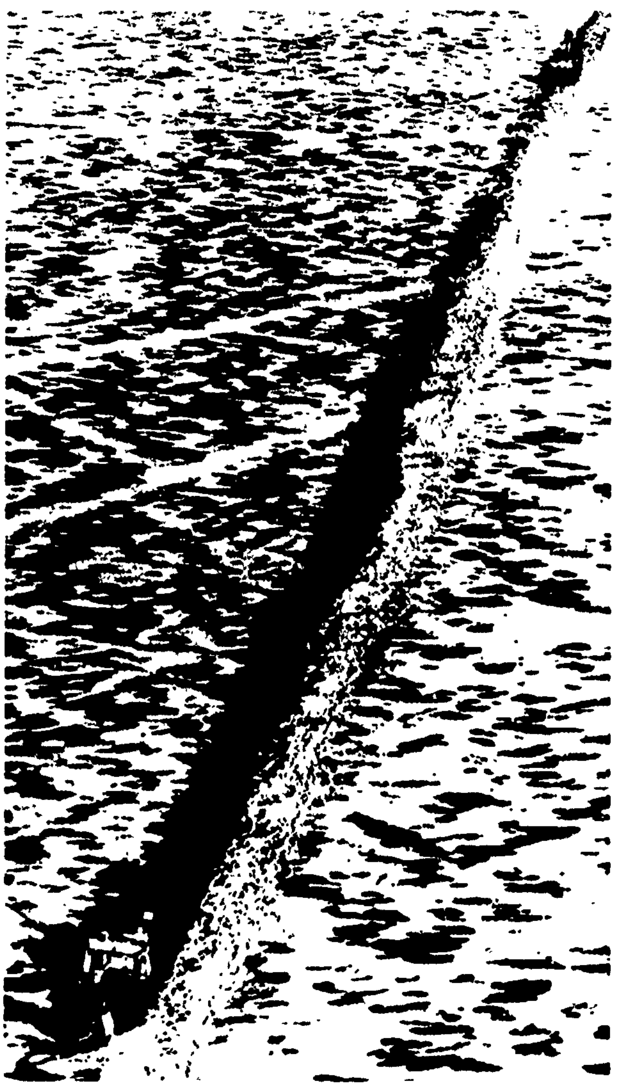
The Treaty of 1909 between Canada and the United States created the International Joint Commission (IJC) and gave it jurisdiction over and authority to act upon matters related to the use or obstruction or diversion of waters of the Great Lakes which would affect the use of these boundary waters by the other nation.

There are two locations in the Great Lakes-St. Lawrence Seaway System at which the flow of water can be completely controlled. These are: (1) on the St.

Marys River at Sault Ste. Marie, Michigan, and (2) on the St. Lawrence River above Massena, New York.

Necessary flow changes are determined and carried out by the International Lake Superior Board of Control and International St. Lawrence Board of Control based on studies authorized by the International Joint Commission.

Coast Guard creates vessel track for ore carrier.



*St. Marys River*

Flow through the St. Marys River is completely controlled in the mile-long reach between the cities of Sault Ste. Marie, Michigan, and Sault Ste. Marie, Ontario. This area originally was a series of rapids which held Lake Superior at an elevation about 21 feet higher than Soo Harbor. A series of four U.S. locks, two U.S. power plants, one Canadian lock and one Canadian power plant utilize an average flow of about 55,000 cubic feet per second. Any excess flow is discharged through a 16 gate control structure located just upstream of the remaining rapids. Under low flow conditions a minimum of ½ gate must remain open to provide flows through the rapids area for environmental reasons.

The amount of flow to be allowed is determined monthly by the International Lake Superior Board of Control. The Board directly supervises the operation of the river control works and diversion of flows to power plants.

Winter outflows through control structures are kept within a range of 55,000 to 85,000 cubic feet per second. Experience has shown that winter flows in excess of 85,000 cubic feet per second can result in the breakup of the stable ice cover formed in the Soo Harbor above the Little Rapids Cut. At times this loose ice accumulates and layers in the Cut to create ice jams which hamper Sugar Island ferry operations and winter navigation, and cause water levels to rise upstream in Soo Harbor. In addition to possible flooding, the rising levels downstream of the power plants lower the head for hydro-electric plants, thus affecting power production.

*St. Clair-Lake St. Clair-Detroit River system*

Except for some drifting ice from Lake Huron and shore ice formation, there is little freezing of the St. Clair River. At the head of the river near Port Huron, Michigan, a natural ice bridge forms a relatively stable ice cover and prevents large amounts of ice from entering the river. When this bridge breaks up (either from natural wind and thaw conditions or ship traffic), significant amounts of ice can enter the system.

This ice can build up at the mouth of the river where it enters Lake St. Clair, in the vicinity of Russell and Harsens Islands, often jamming the channel and creating a potential for flooding. Heavy ice jams in this location also create problems for the movement of vessel traffic and increase the possibility of damage both to the shore and to shore structures.

Three thermal power generating plants are located on the St. Clair River, using river water for cooling purposes. No evidence exists that thermal discharges from these plants have had adverse-to-navigation effects on ice formation in the St. Clair River. It has been shown, however, that as man-made channels are built and deepened, a larger volume of water flows at a faster rate through the river. This decreases ice buildup and lets drift ice flow through the system with less obstructions, thus diminishing flow retardation. This flow retardation has steadily diminished since 1920 mainly as a result of man-made channel activities.

Continued navigation through the ice bridge area at Port Huron may increase ice floes entering the river which would interfere with water intakes. In addition, winter navigation extension may create increased shore and dock damage to the eastern shore of Harsens Island.

A similar problem exists in the Detroit River with the periodic eroding of the ice bridge that forms in Lake St. Clair. Generally, ice floes can pass through the Detroit River into Lake Erie unless easterly winds jam Lake Erie ice into the lower river. Floe ice can back up into the Detroit River to hamper navigation as far

upstream as Detroit. There is concern that winter navigation may cause increased quantities of ice floes to enter the river.

*Niagara River*

At present, no commercial navigation is anticipated for the Niagara River during the ice season. Ice presents problems, however, to power production on the river.

Since the construction of two hydro-electric power plants by Ontario Hydro and the Power Authority of the State of New York (PASNY) completed in 1956 and 1961 respectively, the flow over Niagara Falls has been partially controlled by a 2,120-foot, gated structure constructed downstream of the intakes. By international treaty, a minimum of 100,000 cfs is required to flow over the Falls during the daylight hours of the tourist season and 50,000 cfs at other times.

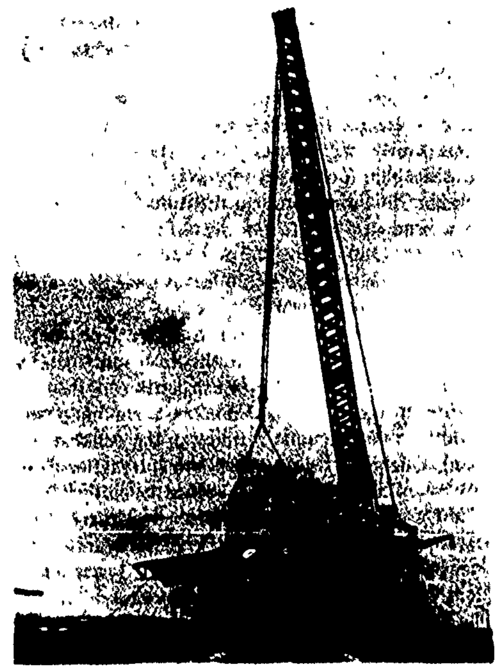
Historically, ice has been a problem in the Niagara River. The Lake Erie ice field, near the entrance to the river, usually arches between the Canadian and the United States shores and restricts movement of lake ice into the river. When the ice is forming, or when the lake is under adverse conditions of wind and temperature, the arch and the ice behind it may break and cause ice to jam in the river above the Falls. The jams can greatly restrict the flow necessary for power production and also cause extensive shoreline damage.

To combat this problem, the two power entities have installed an ice boom at the outlet of Lake Erie every winter since the winter of 1964-65. The boom appears to be effective and has significantly reduced both shore property damage and losses to power production.

Buffalo Harbor, New York, comprised of some 4.5 miles of lakeshore protected by breakwaters, along with sections of the Buffalo River, the Niagara River, and several short ship canals, is normally closed to navigation three to four months each winter.

Because of the prevailing southwesterly winds, and the fact that the capacity of the Niagara River to transport ice is so small in relation to the amount of ice usually present, windrowed ice has traditionally concentrated at the eastern end of Lake Erie during spring breakup in both the pre-boom and post-boom years. The windrowed ice, often several feet thick, usually extends past Buffalo Harbor and into the lake for several miles. Unescorted ship passage through these jams is not possible. Occasionally, even icebreakers have difficulty in moving through this area.

*Winter activity at a St. Lawrence River lock.*



*St. Lawrence River*

The flows in the St. Lawrence River are controlled in three areas. The first area of control is located at the Iroquois Dam and Lock, which extends 1,980 feet between Point Rockway, New York, and Iroquois, Ontario. The dam was designed with the capability to pass or control, if necessary, the full discharge from Lake Ontario. Its gates are used to prevent excessive buildup of water levels in Lake St. Lawrence during periods of strong westerly winds, to minimize adverse currents in the navigation channel of the lower approach to the Iroquois Lock, and to assist in promoting a stable ice cover during periods of ice formation.

The second set of control structures is the Moses-Saunders Power Dam and the Long Sault Dam

located in the Massena, New York-Cornwall, Ontario area, and are used to regulate the outflow from Lake Ontario.

The Long Sault Dam, located below the foot of Long Sault Island, diverts the river flow through the Moses-Saunders Power Plant. Its gates are operated only under high river flow conditions or when flows through the power house need to be restricted for maintenance of generating units. Navigation in this stretch of the river is through the Wiley Dondero Canal and the Eisenhower and Snell Locks.

The third set of control structures is located at the exit of Lake St. Francis where the Coteau Control Dams divert a major portion of the river flow through the Beauharnois Power and Navigation Canal. The Beauharnois Powerhouse, at the outfall of the canal, has a head of 80 feet of water utilized by 36 main generating units with a total capacity of 1,574,000 kilowatts. The remaining flow leaves Lake St. Francis through the Coteau works.

The availability of power in winter depends, essentially, upon the stability of the ice cover. Unstable ice cover can create icejams which can impede the flow of water or block the plant intakes, curtailing power production. When ice is forming in the Beauharnois Canal, Quebec-Hyrdo requests the International St. Lawrence Board of Control to reduce the outflow from Lake Ontario which is accomplished at the Moses-Saunders Power Dam. If the request is approved, Quebec-Hydro follows suit. The River's flow is subsequently increased as ice conditions permit.

Between Ogdensburg and Morrisburg, Ontario-Hydro and PASNY jointly install six ice booms in the International Rapids portion of the River each year near Ogdensburg. The booms assist in the formation and maintenance of a stable ice cover in this area. Two of the booms cross the navigation channel.

## The effects of ice on navigation locks

Continued operation of navigation locks under winter conditions involves several problems related to both floating ice and ice that forms on the structural components of navigation locks.

Ice buildup on the mechanical parts of locks can hinder efficient operation of those parts such as lock gates and safety booms. If the ice is allowed to increase to significant proportions, it may cause structural failure of some lock components. The formation of an ice collar on lock walls may impede or prevent the smooth transit of large vessels.

Floating ice above the lock entrances can block gate recesses delaying their opening. Large amounts of ice pushed in ahead of the vessel may prevent the vessel from completely entering the lock, making it necessary to back the vessel out and flush the ice ahead of it. As vessels entering the locks cut through the ice, the ice may become wedged between the vessels and lock walls. This has the potential of jamming the ship tight. If forces on lock wall monoliths increase, the structures can become unstable. This ice jamming is a particular problem with the V-shaped hulls of "salties."

A problem immediately upstream of the locks at Sault Ste. Marie is the shoaling of bottom material above project depth. This results as a consequence of the more powerful propeller wash in winter that occurs when navigating through heavy ice. A problem immediately downstream of the locks is the buildup of loose ice in Soo Harbor as a result of flushing ice downstream through the locks. An ice barrier often results, requiring icebreaking by a large-class icebreaker.

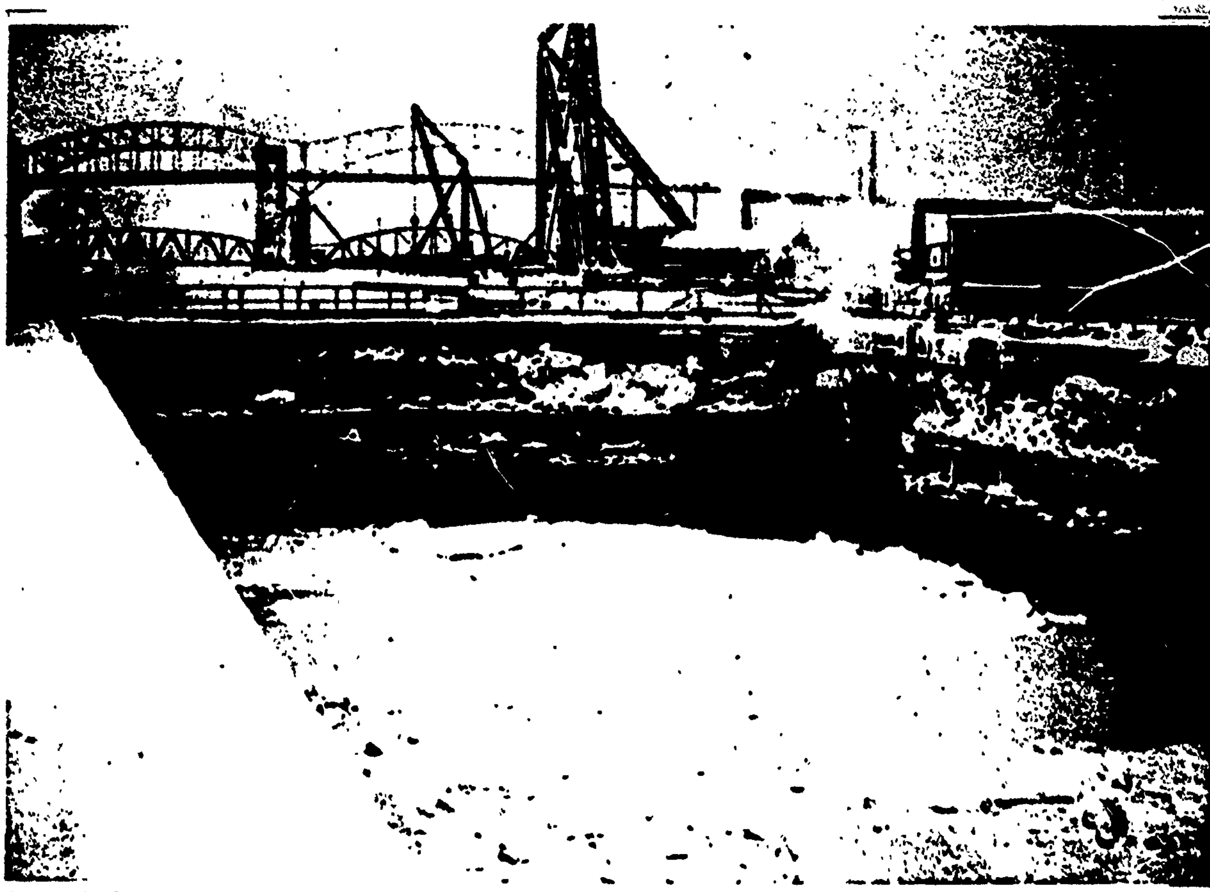
The traditional maintenance period during the winter months will be significantly reduced during an extended navigation season. The reduced working time combined with a higher incidence of wear and tear on the locks due to operations under ice conditions will require a revision of the maintenance schedule.

## Protecting the environment

### *Effects on the shoreline and channel bottoms in rivers, harbors and constricted bay areas*

*Erosion and dock damage:* Increased shoreline erosion and damage to shore structures, primarily docks, can result from winter navigation. When a broken ice pack moves into a restricted channel, shore erosion can occur. This erosion is minimized in areas where shallow water exists along shorelines and where water freezes solid to the bottom. Areas of deep nearshore water may be subject to erosion due to the movement of ice floes as well as from the drawdown effects of passing vessels.

Although shore ice may armor the river bank against erosion, major ship disturbances may shift this ice, creating shore damage and exposing it to additional erosion in the spring. During the spring breakup, artificially high water velocities caused by ship passages may also cause a more rapid ice runout than found in normally low river velocities. Shoreline erosion and surface runoff can have an adverse effect



*Ice on lock gate and wall.*

on water quality in that siltation of spawning areas may interfere with fish egg development. Benthic communities may also be disturbed by siltation.

Drift or pack ice, as well as stable ice, can affect shore structures. Pack ice, because of the pressures generated by its movement, has been known to damage structures, particularly those made of wood; stable ice has a tendency to adhere to vertical piles and piers, with fluctuations of water under the ice cover lifting these structures out of position. This is known as ice jacking.

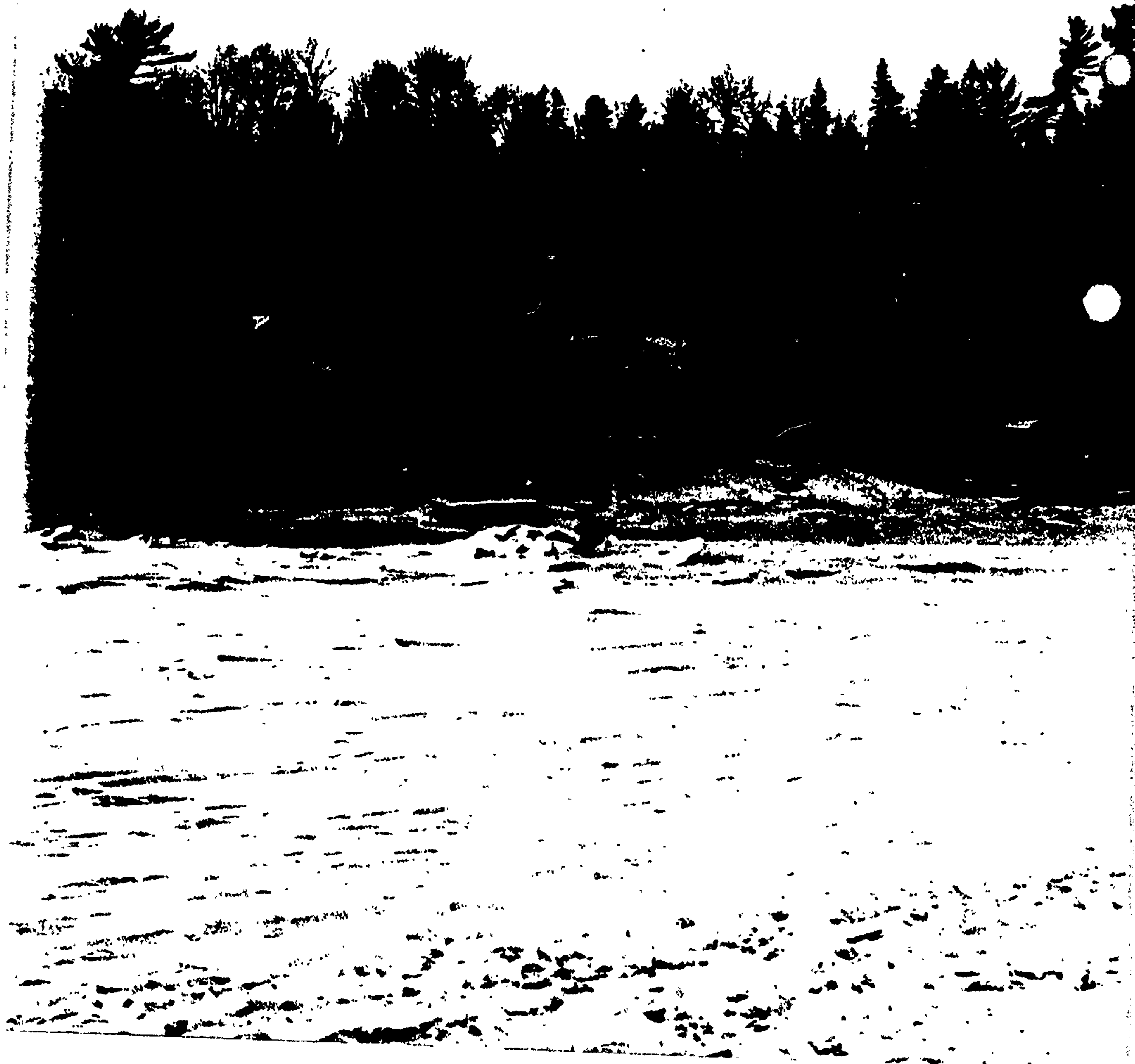
The action of passing ships can also contribute to shore structure damage by intensifying these effects.

*Vibrations:* Adjacent to upper Lake Nicolet, between Frechette Point and Six Mile Point on the St. Marys River, a unique problem sometimes occurs. Local residents have stated that the movement of ships through this reach of the river during ice cover conditions creates vibrations severe enough to cause structural damage to buildings on shore. Although this phenomenon has been reported at several locations within this one area, residents at either end of the reach and at similar areas of the river have not experienced it.

*Bottom scouring:* With the propeller wash of vessels traveling in shallow areas, disturbed bottom sediments, which become suspended in the water, result in increased turbidity and a disruption of benthic communities. Vessel movement through ice requires an increase in the thrust of propellers, creating, a subsequent increase in bottom scouring and its effects.

*Air and water quality*

*Vessel energy usage and air pollution:* Although the Demonstration Program recognized the significant relationship between a season extension and vessel energy usage, along with attendant air pollution potentials, specific studies and experiments have not been conducted with regard to air pollution. Since no site and navigation route, and vessel type and size specific,



system-wide energy usage was demonstrated, only qualitative summarizing statements can be made. The Winter Navigation Board has taken the position that winter navigation will result in a net reduction in energy usage for the nation. There is an additional energy requirement, inseparable from winter navigation, due to the increased level of energy usage for ice breaking, for vessels moving through ice and for the increased vessel traffic. On the balance, studies indicate winter navigation would result in a net reduction of energy usage. This energy savings comes about because of the greater energy efficiency of water transportation as compared to overland modes. Much work needs to be performed to fully document these claims.

*Shore erosion and damage to shore structures was carefully examined during Demonstration Program.*

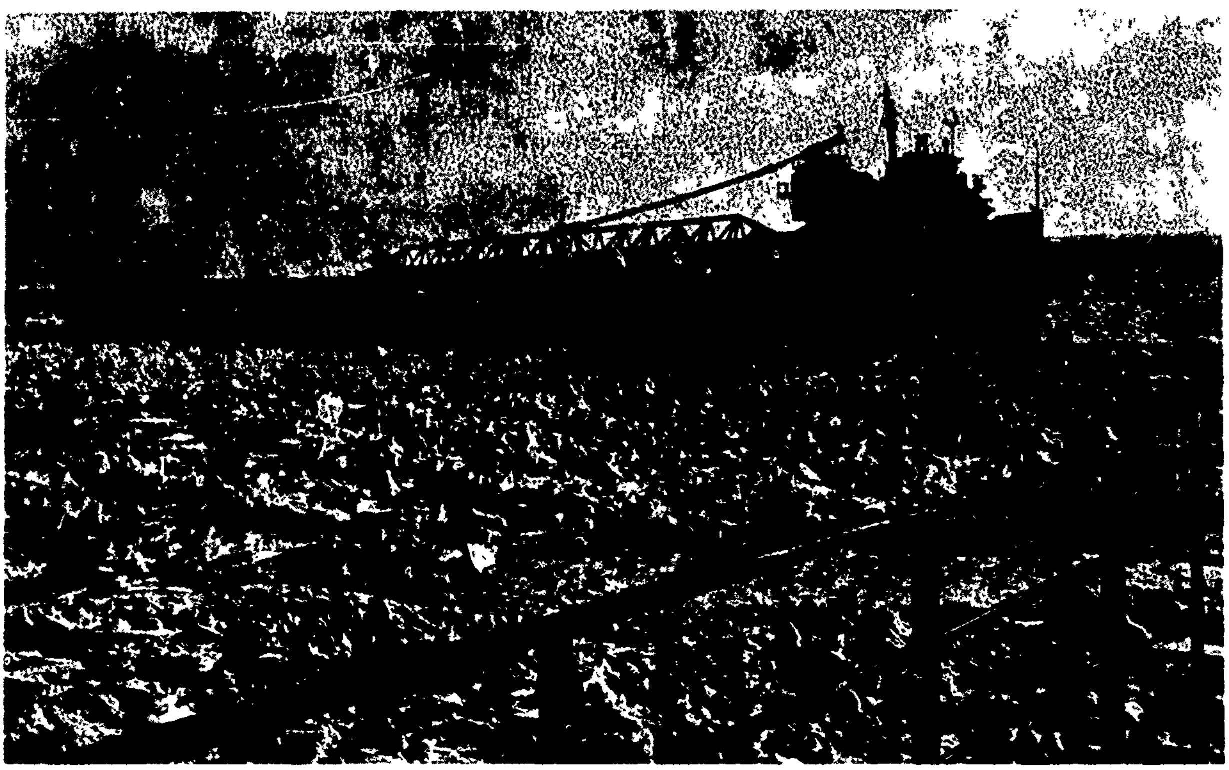
While there appears to be an energy saving and less usage-related air pollution in the National sense there would be an increased energy usage on the system itself. Also some increase of potential air pollution sources is anticipated due to facilities serving winter navigation, such as harbors and locks. This may result in a potential air pollution increase on the system in a qualitative sense. Significant work will need to be executed to define these potential pollution aspects as they relate to the comparatively less sophisticated pollution control facilities of vessels, the increased level of vessel movements, and the applicability and enforceability of air pollution control regulations on international waterways.

*Vessel discharges and regulation:* At present, vessel discharge regulations vary extensively over the Great Lakes and St. Lawrence Seaway System, from state to state, and between Canada and the United States. On the Federal level, the Environmental Protection Agency's (EPA) Standards for secondary effluent are enforced under the Clean Water Act of 1977.

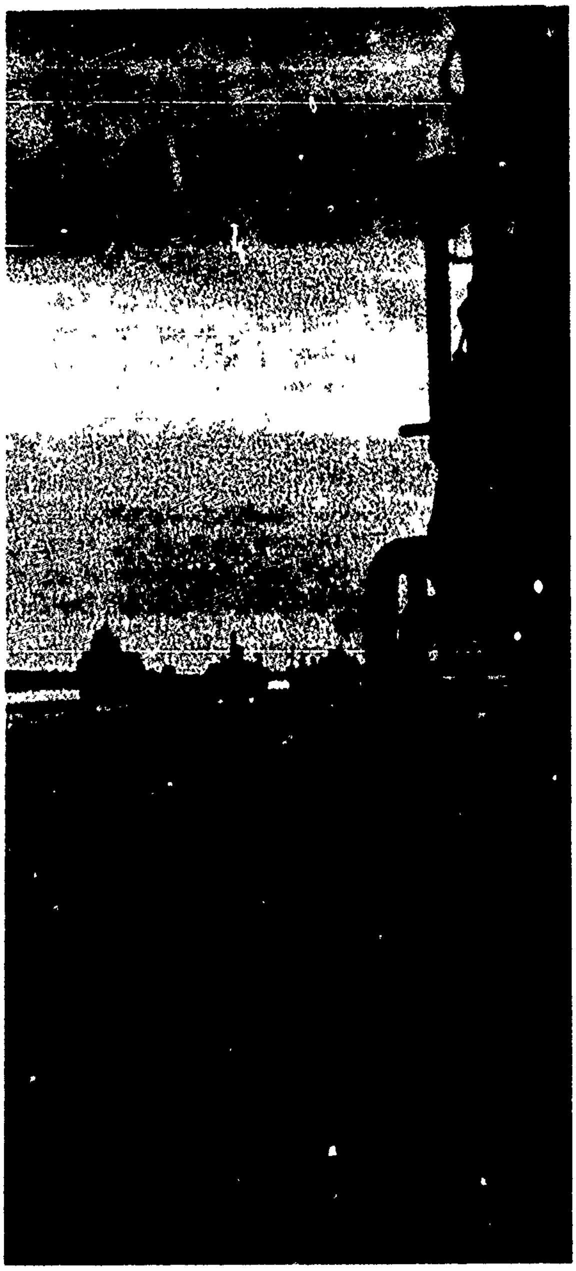
A study of "blackwater" (human body wastes) indicated that no long-term adverse effects were anticipated from additional loadings of treated blackwater wastes from commercial vessels—as a result of an extended navigation season. Although approximately 33% of commercial vessels provide no treatment of blackwater at present, by 1980, the discharge of untreated sewage by commercial vessels will be illegal. These regulations will require Coast Guard certification.

"Greywater" commonly refers to domestic wastewaters generated from galleys, laundries, showers, sinks, and miscellaneous small sources such as drains and drinking fountains located throughout the ship. There are currently no regulations pertaining to greywater unless it is included in the same wastestream as blackwater.

*Turbulence caused by vessel propellers:* The activities of icebreakers and commercial vessels during the Demonstration Program in shallow bays, harbors and connecting channel areas of the Great Lakes System have caused varying degrees of water turbulence, turbidity and bottom erosion. During both



*Ice strengthened* Henry Ford II *moves through ice field.*



*Underway in heavy ice.*

winter and summer months, a resuspension of both polluted and unpolluted bottom materials occurs as a result of this vessel movement, disturbing fish and wildlife habitats as well as water quality.

Although this turbulence has been only partially investigated, it can be concluded from the investigations on sediment transport and shoreline erosion conducted by the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) that the environmental effects of vessel movement are restricted to only the shallower areas of the Great Lakes System. Areas in this category include the St. Marys, St. Clair and Detroit Rivers; small portions of the St. Lawrence River; Lake St. Clair; western Lake Erie; bay areas such as Green Bay, Saginaw Bay and Maumee Bay; and the harbors in the system. With the exception of the harbors, these areas are also the most biologically sensitive and productive in the system.

Water turbulence is caused primarily by icebreaker and vessel propeller wash, by ice chunks driven into the bottom, and by ship-induced waves. Vessel propellers normally generate high velocity currents at or near the bottom that resuspend particulate material within and adjacent to the vessel channels. In ice-covered areas, where more power is required to move a vessel, the area of the bottom disturbance is increased.

Under ice conditions, ship-induced waves and high velocity currents have been found to stir and erode bottom materials outside vessel channels, particularly in shallow areas of connecting channels. These induced waves and currents were found by CRREL to frequently cause normal river currents to take a 360° turn in direction. The velocity of the turning current was also found to be much greater than that of the normal downstream current. The rotation of the normal current direction and the great velocity of these redirected currents result in stirring and resuspending bottom substrate materials.

In addition to rotating the direction of the normal current, ship-induced waves also cause a withdrawal and a surge of shoreline waters. In one area of the St. Marys River, the withdrawal and surge of under-ice water has been documented on at least one occasion to have an energy force sufficient to cause a breakup of the shoreline ice cover, forcing fish, aquatic vegetation and bottom material through breaks in the ice cover.

In addition to eroding the bottom substrate, this kind of turbulence in the water is capable of causing physical injury to fish, and such turbulence, even of a lesser magnitude, can be expected to render the habitat less suitable. The shifting of the bottom substrate as a result of the withdrawing and surging waters also

creates an unstable habitat for benthic communities.

Comprehensive studies determining the extent of impacts of ship-induced turbulence on the fish and benthic communities have not been conducted during the Demonstration Program. Observed effects, however, warrant thorough investigation and the discovery of means to eliminate or minimize the losses.

*Disruption of solid ice cover*

*Recreation:* Recreational activities on the ice-covered connecting channels, harbors and bays of the Great Lakes include ice fishing, snowmobiling, cross-country skiing, snowshoeing and hiking.

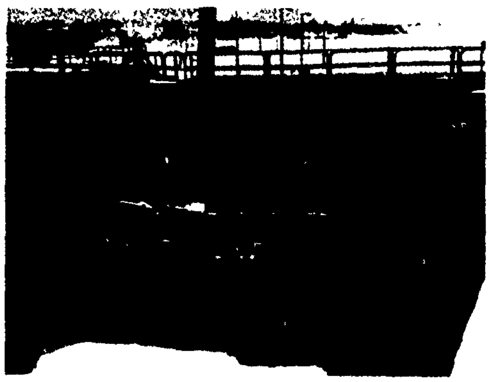
Ice fishing has probably been the most affected by the Navigation Season Extension Demonstration Program because more people participate in this activity than the other sports. In areas such as the St. Marys River, complaints have been received from local citizens claiming that ice fishing has become unsafe as a result of the Demonstration Program. The primary reason they have given is that vessel movement causes the ice cover to crack, break and heave from vessel-induced waves.

It will be important to determine the location of existing and pre-demonstration fishing areas and determine what effect Winter Navigation has on them.

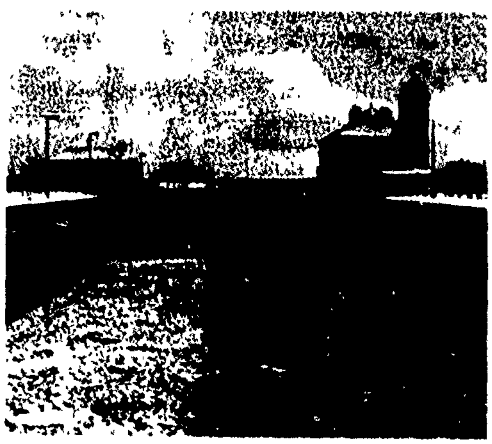
*Commercial fishing:* The Demonstration Program has resulted in reported difficulties with winter commercial fishing activity. The problems have not received in-depth investigation, but Saginaw Bay has been identified as one problem area. Commercial fishing in this bay is reduced because moving ice, caused by a vessel track through the ice cover, often seriously damages gill nets. Additionally, vessel tracks may prevent access to traditional fishing grounds.

*Wildlife migration:* Ice cover over connecting channels, lakes and bay areas provides animals a more available means of moving from one land area to another. This movement, often involving a search for additional food supplies during the winter, offers valuable opportunity for the change of gene strains of island populations. Few studies have been undertaken during the Demonstration Program to identify species that use ice cover for winter movement, the locations, or the extent of this movement, but movement of mammals across the ice has been observed. According to the National Park Service, this is the means by which Isle Royale in Lake Superior may have been colonized by moose and wolves.

It is possible that the St. Marys River ice cover



*Build up of ice on MacArthur Lock gate.*



*Ice in lock at Sault Ste. Marie.*

may be an important link for maintaining balanced animal populations. Species that may be adversely affected by a breaking of the ice cover include the whitetailed deer, moose, bobcat, red fox, coyote, and possibly the endangered grey wolf. Winter movement of these and other animals may occur between the mainlands of Canada and the United States and between the large islands and the mainlands. The presence of a ship track will not prevent this movement but may be a deterring factor.

Waterfowl may be stopped from migrating to more southern ancestral wintering habitats by open water areas created by extended season activities. It will be necessary to determine what effects winter navigation will have on wildlife migration and wintering waterfowl.

*Island transportation access*

***Sugar Island and Little Rapids Cut:*** Downstream from the Sault Ste. Marie locks the ice cover in the Soo Harbor and the ice bridge above Little Rapids Cut can break under high wind or thaw conditions and move downstream, sometimes causing ice jams in the lower Little Rapids Cut. The continual movement of vessels during the winter increases the amount of broken ice that could jam in the Little Rapids Cut and subsequently causes disruption to the Sugar Island ferry which provides service to about 450 permanent island residents.

If the ferry track becomes filled with ice or ice builds up in the mainland ferry slip, the ferry is unable to operate. A strong cross current on the island side normally keeps the island slip clear of ice. There is no cross current on the mainland side and drift ice entering the slip can make landing difficult or impossible.

The Sugar Island ferry initially had limited ice operating capabilities. Its ability to operate in ice conditions was subsequently improved for operation during the Demonstration Program.

*Industrial stockpiling — costly alternative to water transportation.*

*Neebish Island and West Neebish Navigation Channel:* The Neebish Island ferry currently stops operating when ice begins to develop. Accessability to the mainland for the island's 30 to 50 winter residents resumes when the ice becomes thick enough to support foot or snowmobile traffic. At this time, downbound vessel traffic is directed to the Middle Neebish Channel and does not disrupt normal access to the island.

If the West Neebish Channel is used for future winter navigation, the island will be isolated from the mainland; access problems will be created similar to those experienced by the Sugar Island residents. (A particular problem in the Middle and West Neebish Channel is that neither channel can accommodate two way traffic without a traffic control mechanism. During the normal navigation season, the Middle Neebish is used as the upbound channel and the West Neebish is

used as the downbound channel.)

*Lime Island:* With the advent of winter navigation, ship tracks cut through the stable ice cover between inhabited Lime Island and the Michigan mainland, destroying the ice cover access which was historically used by the island's winter population of about 10 adults. The residents of Lime Island are employed by a private company which is located on, and also owns, the island.

*Drummond Island and DeTour Passage:* Year-round access for Drummond Island's 600 permanent residents is provided by a ferry across the mile-wide DeTour Passage. Historically, ferry operations have been hampered by ice blown north from Lake Huron. The ice jams against the stable ice bridge which normally forms across the Passage upstream of the ferry crossing in the vicinity of Pipe Island. Northerly winds tend to clear the passage south of this ice bridge, but frequently loose ice is blown along the shoreline at DeTour and/or Drummond Island. The ice tends to compact in the ferry landing slip and hampers ferry docking procedures.

Commercial navigation through the solid ice field in DeTour Passage has not affected its overall stability. Some loose ice dislodged at the edge of the ice bridge at the navigation track may drift away under northerly winds reportedly hampering ferry operations, but the large areas of ice are not affected by the relatively narrow navigation track.

Winter navigation during the Demonstration Program has interfered with an alternative mode of transportation to Drummond Island: snowmobiles can no longer safely utilize the stable ice bridge north of the ferry crossing because of the vessel track which is reopened with each ship passage.

*Historical and cultural resources*

Cultural resources include almost anything that affects the daily living patterns of people in a given area. They can include items such as land use; number and location of public, commercial and individual facilities; and recreational habits and sites used by local inhabitants. Historical resources consist primarily of buildings or sites relating to events important to an area's past, or representative of past living modes.

Negative impacts on these kinds of resources may result from changing ice forces, from potential changed water levels caused by ice boom modifications, and from the results of ship transits through ice. These negative impacts include both the possibility of increased shore erosion and potential damage to structures located in or along the water. As well, any activity change from the norm (such as the disruption of recreational fishing) could be considered a negative effect on an area's cultural resource.

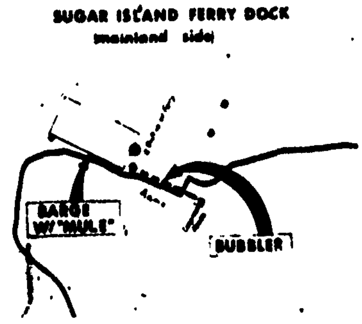



*Diagram shows Sugar Island ice control activity.*

*Bubbler/flusher system at work at Sugar Island Ferry Dock.*

To minimize any possible negative effect on these resources, a complete inventory is necessary to identify existing resources and to develop plans which will minimize the negative impacts on them, should they occur. (Erosion and structural damage control measures are discussed later in this report.)

*Local climatology*

*Buffalo, New York:* Each winter since the winter of 1964-1965, an ice boom has been placed at the mouth of Lake Erie above its outlet into the Niagara River. The boom is installed under International Joint Commission authority by the Power Authority of the State of New York and Ontario Hydro. The purpose of the boom is to enhance the formation of a stable ice cover in early winter (which occurs naturally at the boom site anyway) and to dampen the effects of the late winter wind-generated ice runs. This mitigates ice control problems at the downstream intakes of the power entities. Such problems in pre-boom years led to serious ice jams in the river, resulting in reduced power diversions and the ensuing increased energy losses. Heavy ice runs also caused extensive damage to shoreline property along the Niagara River.

Studies conducted throughout the fifteen-year post-boom period show that the ice carrying capacity of the Niagara River is virtually insignificant when compared to the natural rate of dissipation of Lake Erie ice by melting in place, and to the enormous amounts of ice present on the lake (often ten thousand square miles). However, small amounts of ice, in terms of the total amount on the lake, can have disastrous effects on the Niagara River.

The installation of an ice boom, at the head of the Niagara River near Buffalo Harbor, is felt by some, to prolong the period of ice cover. Notably, in this area, the U.S. Lake Carriers' Association felt that the start of the navigation season was unnecessarily delayed due to this effect. The Council of the town of Fort Erie, Canada, also felt that the ice field restricted recreational sports and deterred the flow of tourist dollars into that area.

Although it has been shown that the water temperature regimes have been lower during April in the post-boom years, there has been no evidence of any effect of the boom on local climatology, navigation, or recreation by any of the many technical studies performed to date by the IJC, its cooperating agencies or independent investigators.

The theory has been proposed that the boom may, in fact, reduce the severity of the Lake Erie ice cover since a stable ice cover is less subject to windrowing and dense packing. This theory has not been substantiated by factual data, nor have any claims that the boom extends the ice season.

The boom does not intersect any commercial navigation routes, and, therefore, has no known effect on existing commercial navigation.

*Vessel tracks at St. Marys River.*

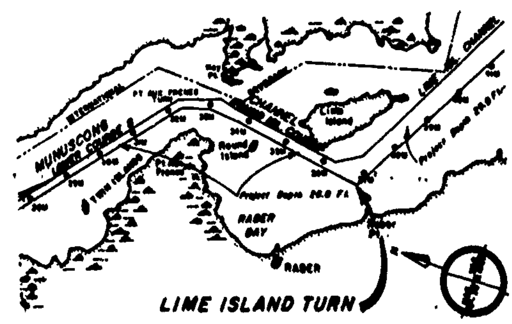



*Diagram shows Lime Island Turn.*

*Great Lakes/Seaway Region in general:* Atmospheric temperature inversions, a common phenomenon during the spring warmup period, occurs over the Great Lakes region. This inversion is created when warm air masses pass over cold lake surfaces and become chilled. A result of a temperature inversion is the development of an interface separating the upper warm air mass from the lower colder air mass. As a result, gaseous discharges into the bottom layer become trapped and air quality deteriorates in regions having sufficient gaseous discharges, if the inversion phenomenon extends over a prolonged period. Any activity which tends to upset normal heat transfers between the Lakes and the atmosphere could cause a change in local microclimates.

*Working in winter*

*Rescheduling vacation time:* Four occupational groups have been identified as being directly affected by winter navigation activities: vessel, terminal, lock and pilot personnel.

Vessel personnel include about 5,000 people at the peak of the shipping season. These employees are assigned to vessels operating with about 30 men per ship.

U.S. and Canadian piloting personnel throughout the System number about 155, and maintain a seasonal lifestyle of spring, summer and fall employment, with the winter months open for vacation or recreational activities.

With winter navigation, seasonal employment for these groups would change to year-round employment.

Terminal and dock personnel are usually employed year-round and, although season extension would not materially affect their work, their specific duties would change with a navigation extension.

There are about 4,000 persons employed in terminals at the peak of the season, and another 350 employed at the Sault Ste. Marie and St. Lawrence Seaway locks. Changes, both in the work activities and vacation schedules, would emerge from an extended season effort.

*Working in cold weather environments:* Winter weather, of course, poses certain problems for people working in the winter months. Productivity is obviously affected due to time required for snow removal, and the movement of bulk cargo can create handling problems should they freeze into large chunks.

Equipment used in winter requires longer start-up periods. Year-round use also eliminates overhaul time, and may necessitate the purchase of additional equipment.

The safety and dress of workers in winter conditions is also a major item of concern.

*Moving oil and hazardous material during winter*

Heating oil, gasoline and benzine are generally the only hazardous materials moved in quantity on the

*Ice boom constructed with an open water navigation channel through the ice cover.*

Great Lakes during the winter months. Few, if any, spills occur. The Coast Guard has indicated that winter navigation does not include an inherently higher risk of spillage. Historically, most spills are related to wave damage and grounding. Ice cover significantly reduces the potential for these types of incidents.

Consistent concern has been expressed by some local residents as to the ability of the Government to adequately contain and clean up such spills before irreversible damage occurs in the environment.

The Department of the Interior and Environmental Protection Agency have concluded that present day technology to clean up spills in ice covered fluvial waters of the connecting channels is inadequate to protect fish and wildlife resources and their habitats.

## Defining costs and benefits

As part of the overall Great Lakes and St. Lawrence Seaway Navigation Season Extension Survey Study, problems have been identified and solutions developed and tested under the Demonstration Program in order to show that winter navigation is possible. Many of the Demonstration Program's activities were conducted in one location which is representative of several areas. Then, too, many solutions to problems required the development of new hardware and techniques at costs considerably greater than those for standard, commercially available material, if they could be used.

It becomes apparent, therefore, that costs in a Demonstration Program may not be representative of those occurring in a normal system-wide program. At the same time, the use of experimental costs prohibit the establishment of an accur *• cost-to-benefit ratio for the Demonstration Progra. . itself. Costs of each demonstration project are accurately recorded for consideration in the overall feasibility study.

## Canadian co-participation

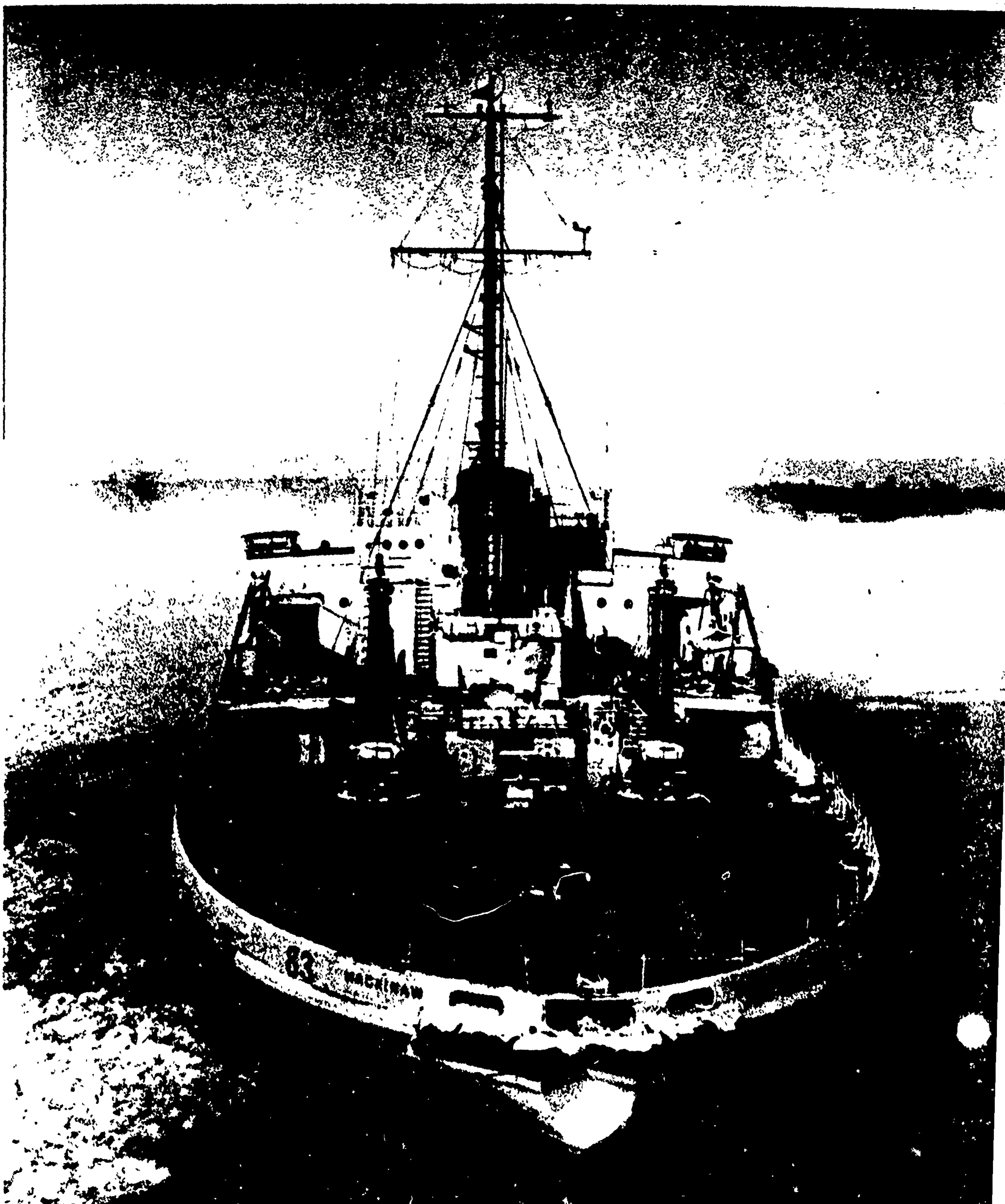
For any system-wide season extension program to become a reality, Canadian co-participation is vital. In addition to sharing ownership of the system, the major portion of the St. Lawrence River, the system's link to the world's oceans, is within Canadian boundaries. Its Seaway facilities are under the jurisdiction of the St. Lawrence Seaway Authority of Canada.

The system below Montreal currently enjoys year-round navigation. Sharing such a vast resource, Canada has an obviously large stake in any extended navigation season, and especially as it relates to the movement of goods to and from foreign countries.

Cooperative relationships with Canada are critical to the success of the program.

## Public involvement

An important ingredient of the Demonstration Program has been the public involvement program, in which various publics have been informed about the first actions and results of past studies relating to the winter navigation efforts. Comments and suggestions were and will be continually encouraged from groups and individuals in order to allow the Winter Navigation Board to gain the widest input possible and to direct activities acceptable to all levels within the constraints of the Program. This type of public input served to focus on many of the problems facing the program such as shore erosion and structure damage, island access difficulties, and the need for comprehensive environmental studies.


83
MACKINAW

*After view of the* Mackinaw.

# III. ACTIVITIES TO DATE

## Assisting vessels through ice

*Icebreaker support*

One of the primary activities pursued by the Great Lakes Demonstration Program was the overall objective of safe and efficient movement of vessels through ice-covered waters. The major responsibility for this effort fell to the U.S. Coast Guard with its icebreaking activities.

*Coast Guard vessel fleet*

In the Great Lakes-St. Lawrence Seaway System two large icebreakers are used to facilitate extended season vessel movement in ice-covered waters. In addition to these two vessels, one of which is the Great Lakes icebreaker *Mackinaw*, a number of smaller cutters are normally employed in rivers and narrow channels to maintain traffic flow.

During the demonstration effort, Canadian icebreaking vessel activities were coordinated with those of the U.S. Coast Guard. Section 2 of Title XIV, U.S. Code was amended by PL 93-519 to authorize such cooperative icebreaking activities on a seasonal basis.

*Preventive icebreaking*

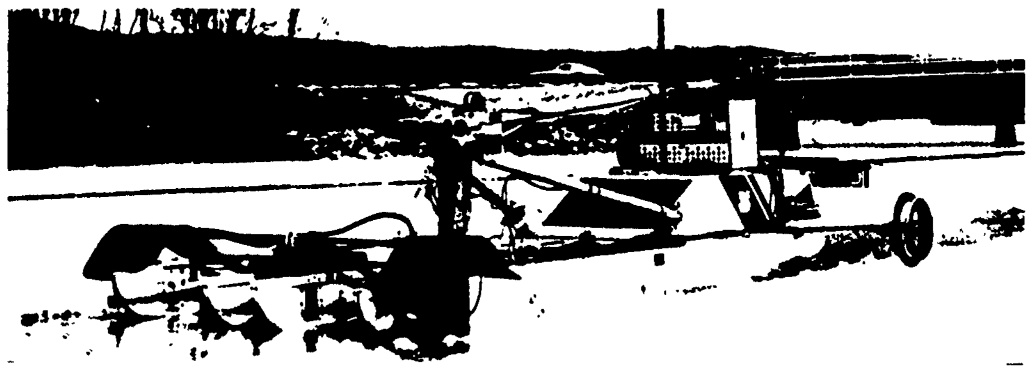
Preventive icebreaking has proved to be an excellent alternative to single ship escort in many areas of the Great Lakes. This activity involves opening and then maintaining tracks through the ice for large vessels to follow to their destinations unescorted.

*Convoy travel*

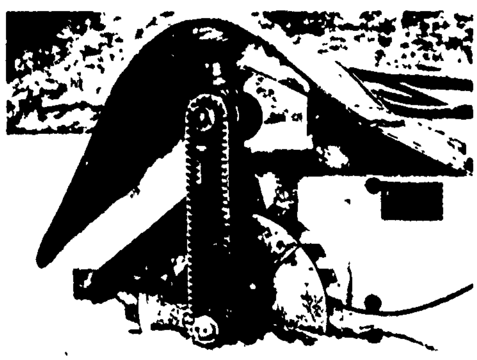
During the latter years of the Demonstration Program, the use of convoys have proved to be effective in reducing the work load of the icebreaker fleet. In this case, ships are assembled at a given point and are assisted to their common regional destinations by an icebreaker.

*Joint U.S. Coast Guard-Canadian Coast Guard Guide*

To facilitate the transmittal of information on icebreaking techniques and policy utilized during the Demonstration Program period, a joint U.S. and Canadian icebreaking guide was developed and distributed to all U.S. and Canadian shipping companies each year of the program.



Scale model mechanical ice cutter.



Ice saw.

*Non-conventional icebreaking*

Several methods of icebreaking were tested during the period covered by the Demonstration Program. The tests were conducted in various locations both within and outside of the Great Lakes Basin. Not all tests were funded directly under the Demonstration Program. Information obtained from these tests have indicated that none are universally implementable under conditions found on the Great Lakes and their connecting channels.

A submerged icecracking engine was tested on Muskegon Lake near Muskegon, Michigan. This device breaks up ice by periodic sudden release of high pressure combustion gases underneath the ice. An operating form of this device would be ship-mounted for navigation channel clearance in lakes and rivers. Tests indicated that this device could clear a channel 40 feet wide through ice two feet thick at a rate of five MPH. A drawback for this type of icebreaking device is that it requires a substantial increase in the power supply of the accompanying vessel.

Experiments were conducted to determine the power requirements of cutting ice with high pressure water jets. Tests were conducted near Houghton, Michigan, under conditions that yielded ice thicknesses of at least two feet. It was determined that this form of icebreaking was not feasible because it required excessive power plants and the current state-of-the-art for necessary high pressure waterjet equipment was not reliable.

The operation of a mechanical ice cutter (MIC) was also investigated. The MIC consists of circular saws mounted on the forward bow of a barge. When the barge is pushed into the ice field, two longitudinal cuts are made. Once cut, the sides break, bending under the cutter barge, and are deflected laterally under the adjacent ice sheet . a skeg, mounted beneath the barge. It was thought that the MIC would leave in its wake an ice free channel. But it was found that the cleared channel would refreeze and with each vessel passing a new frozen cover with significant brash content would occur It was also found that breakage of adjacent ice cover by vessel waves added to the brash content in the channel.

*Air cushioned vehicles*

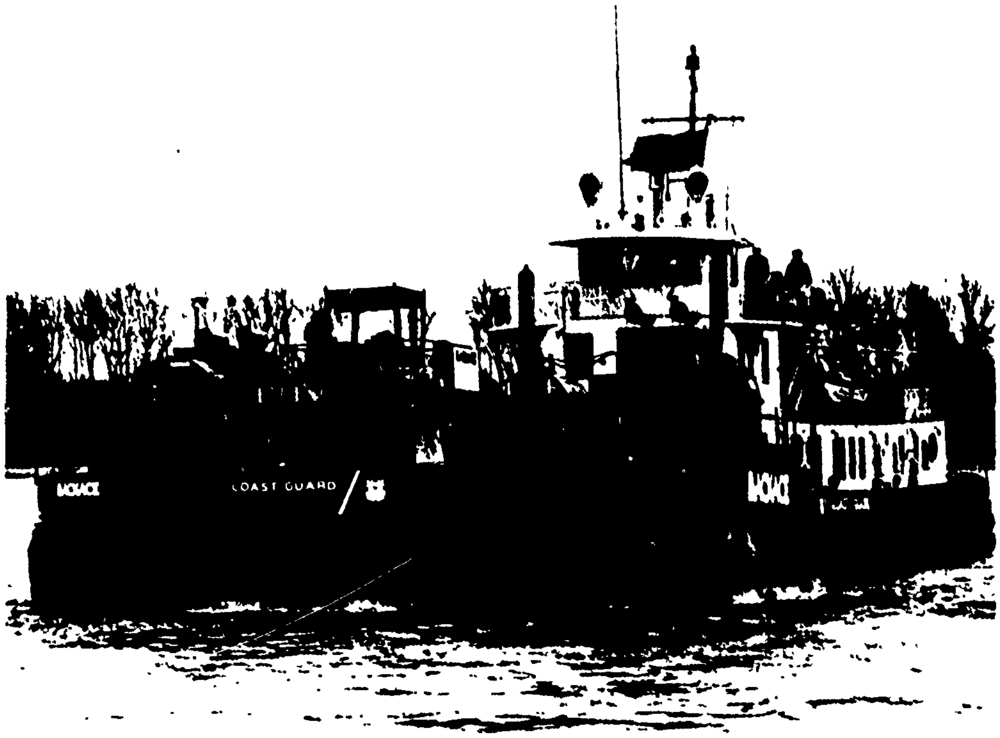
During the winter of 1975-76 Transport Canada conducted tests of a new icebreaking method at Thunder Bay, Ontario, using an air cushion vehicle, *Iceater I*. This vehicle is a modified ACT 100 hovercraft with a 14 foot "V" notch cut into its hull to accom-

*Canadian icebreaker pushes air cushion vehicle unit during Lake Superior tests.*

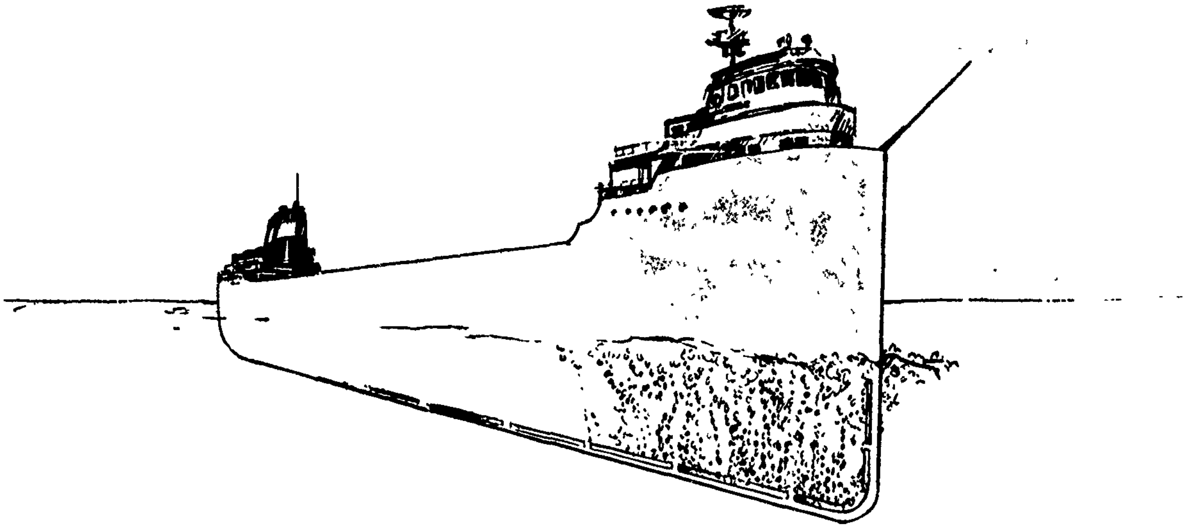
modate the bow of a powered vessel. The U.S. Coast Guard performed tests during the winter of 1977-78 using air cushioned vehicles as icebreakers on the Illinois and Mississippi Rivers. Vehicles tested included both bow mounted and self propelled vehicles. All vehicles tested were successful in varying degrees in use as icebreakers.

While all these tests showed the various devices are feasible as icebreaking methods, available technology does not necessarily make them practicable. Additionally, test locations do not ensure that the results are universally applicable for use under conditions found on the Great Lakes and their connecting channels.

*The* Mackace, *a bow mounted air cushion vehicle.*



*Artist's interpretation of air bubbler system on ship hull.*



*Air bubbler system on vessel hulls to ease transit*

An air coating system on a vessel's hull was designed to produce and direct a uniform coating of air around the vessel's hull, thereby reducing the amount of friction a vessel would encounter while moving through ice fields. The system consisted of a series of manifolds located external to the ship's hull, with each mainfold connected to an air supply line. The rapid expelling of large quantities of air through the small holes in the mainfold caused an upswelling of water to accompany the air. This combination of air-water mixture provided a lubricating film between the ice and the hull. Gauges were placed on the hull of the testing vessel to measure forces caused by movement through ice. Tests demonstrated that the test vessel did show reductions in friction while moving through ice. They also indicated the practicability of designing air manifolds to allow a uniform air coating to be obtained at various drafts and trim conditions. It has not been determined whether or not such a system is an economical solution to this problem.

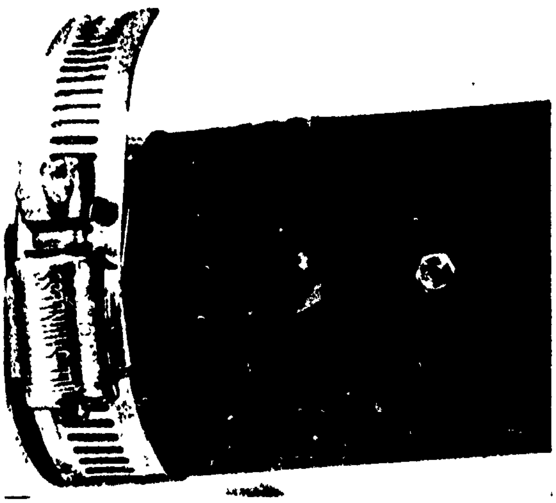
*Air bubbler systems to suppress ice in channels*

An air bubbler system produces rising air bubbles which move the slightly warmer bottom water to the surface, where it melts ice or reduces ice thickness, easing a ship's passage. An onshore air compressor feeds air through a supply line to a flexible perforated bubbler pipe anchored along the channel bottom, where its small holes -- 10-15 feet apart -- cause a bubble stream to move continuously upward, creating a current to the surface The bubbler pipe floats above the contour of the bottom, supported by ropes secured to concrete block anchors.

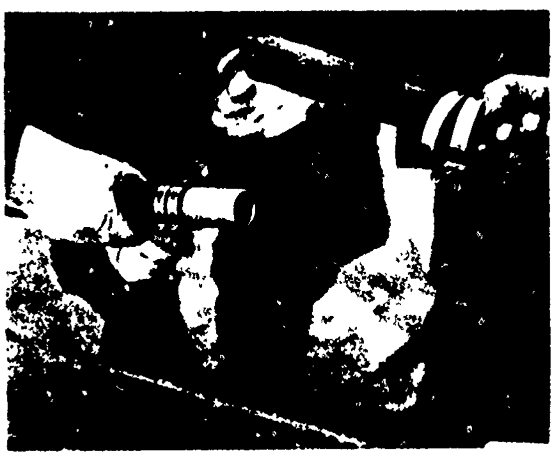
Bubbler systems were tested for three winters (1972-75) at the Duluth-Superior Harbor to determine the effectiveness of the system over various configurations and locations within the harbor. During FY 73 a loop bubbler system was installed on the west side of the Superior entry to the harbor. The site was chosen because late shipments of ore were scheduled to be made that winter to nearby docks. The bubbler system was intended to furnish information on the problems involved in installation and data on the effectiveness of the system in facilitating movement into and out of the docks. Environmental effects resulting from operation of the system were monitored prior to installation, during operation, and after shutdown.

Another bubbler system was installed at the Duluth-Superior Harbor in and adjacent to Howards Bay to obtain additional information on the costs and problems involved in installation and maintenance of bubbler systems and to further evaluate its effectiveness in facilitating vessel movements in harbors. This site was chosen because two vessels were to arrive at nearby shipyards located within Howards Bay during early February 1974 for structure modifications. Again, the environmental effects were monitored by a consultant. During operation, the system was damaged twice by passing ships. Both times, after the system was repaired and operation resumed, the ice was dissipated rapidly.

The bubbler system in the Howards Bay area of Duluth-Superior Harbor was again used during the 1974-75 winter season for the purpose of examining the impact of such a system on water quality.



*Section of bubbler pipes shows small hole through which compressed air is released.*



*Air bubbler pipe laying operation.*

*Vessel track.*

*Vessel track is apparent in this St. Marys River photo.*

The bubbler system at the Superior entrance to the Duluth-Superior Harbor extended shipping at the docks until 1 January 1973. A severe early winter caused a heavy buildup of ice at the docks, cutting short the scheduled extension of ore shipments by about one week. The vessels had no difficulty in maneuvering in the bubbler area.

The bubbler system at the Howards Bay location was operated until 19 February 1974. The system performed well during the test period, succeeding in keeping an area 25 to 40 feet wide clear of ice over the length of the bubbler and with greatly reduced ice thickness extending an additional 20 feet on either side.

The bubbler system also proved to be environmentally acceptable with no serious adverse effects observed during three years of study. The system appears to be practical and suitable for use over a wide variety of applications and locations.

In the St. Marys River, at the Lime Island Turn, a bubbler system was used in the winter of 1972-73 and again in 1973-74 This location was selected because ships experienced unusual difficulty in negotiating the sharp 70° turn in a stable ice field that produced as much as three feet of ice. The water depth was about 55 feet and current velocity was relatively low (less than one-half foot per second). This test used a 5,000-foot supply line from the Island connected to a 3,000-foot bubbler pipe located on the channel bottom.

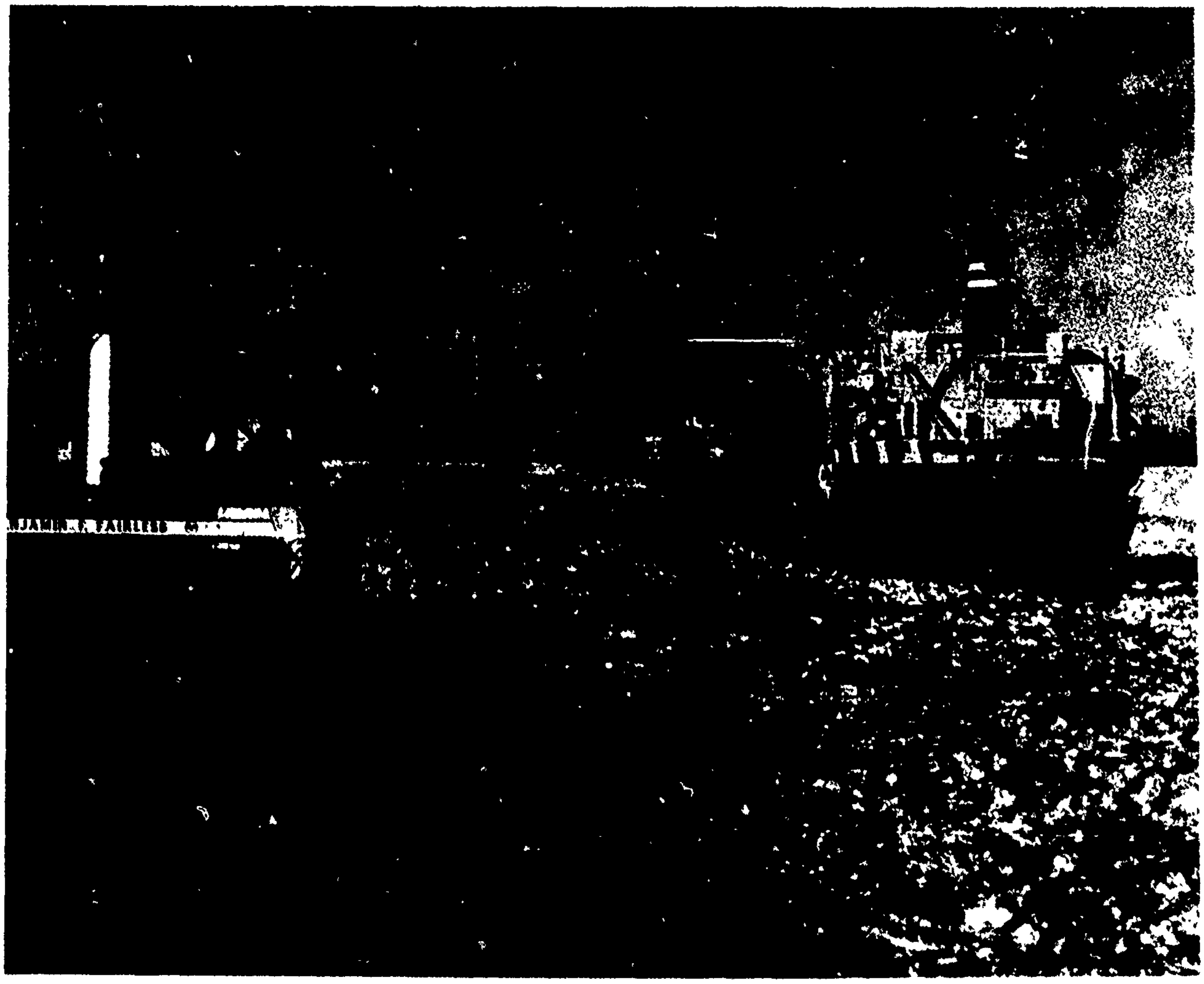
The Lime Island Turn bubbler installation performed well. Ice thickness was negligible directly over the diffuser pipe. The installation significantly aided vessel passage through the Turn, although it was learned that ships had to pass directly over the bubbler center line in order to achieve maximum benefit.

Vessel masters traversing the St. Marys River during the extended navigation season reported that as a result of the bubbler system they were able to negotiate Lime Island Turn without difficulty. They suggested that the bubbler line be lengthened to include more of the turn, and some expressed the opinion that there was some decrease in ice thickness downstream from the turn because of the bubbler operations.

*Thermal ice suppression*

A test was devised during the Demonstration Program to investigate the use of thermal discharge from industry and power production in various locations around the Great Lakes as a means of facilitating winter shipping. A thermal suppression system is very similar to an air bubbler system in that warm effluent water is released through a diffuser pipe

*View of convoy.*



to reduce ice thickness or to prevent ice formation in a navigable waterway.

Through the end of FY 75, efforts were made toward site selection, a feasibility study, the collection of environmental baseline data for several years prior to testing, the design of a pilot test facility, and the purchase of equipment. A number of locations were considered. Saginaw Bay, at the mouth of the Saginaw River in Lake Huron, was finally selected as the best site to study the thermal ice suppression process. Equipment was installed and tested in FY 76.

The thermal ice suppression demonstration was conducted using heated effluent from a power plant located near the test site. A feeder pipe was installed to the navigation channel and a diffuser pipe 800 feet long was laid along the channel edge.

The heated effluent was discharged through a series of nozzles positioned at angles of 0° to 45° and 90° to the channel bottom. Test data was collected throughout the winter to determine the horizontal extent of the effects of the heated water, its effectiveness and its environmental impacts. Substantial ice melt, which was anticipated, did not occur. The thermal plume from the horizontal and 45° diffuser nozzles did

*Gathering ice information.*

not melt surface ice. However, the verticle jets did produce open water areas. The potential of combining an air bubbler system with warm water discharges was favorably discussed but no studies were performed.

## Navigation aids, devices and systems

### *Prototype ice buoy tests*

A regional deterrent to winter navigation in the confined waters of the Great Lakes St. Lawrence Seaway System is the removal of the conventional buoys by the Coast Guard as ice begins to form. These buoys are removed to prevent their being moved off station, or capsized by ice.

Based upon admittedly limited experience, the Coast Guard, in 1972, designed six buoys to withstand the rigors of the ice environment. Various sizes were designed to ascertain cost ratios, ice accumulation on superstructures and handling capability. Of the six, two were stock items from the Coast Guard's existing inventory of ocean buoys. These were modified by removing open cage ladder-style superstructures and installing cylindrical 12 inch diameter tubes to support beacons. This modification reduced the affected area of ice accumulation.

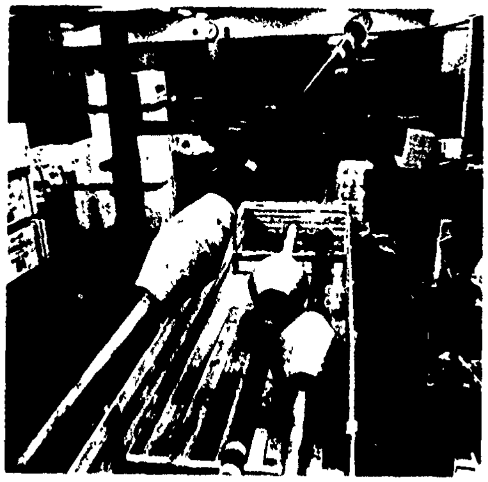
One of the buoys was 9 feet in diameter and 20 feet long, with a conical base. Under high forces, the sloped edge of the base could assist the buoy to ride up to the surface of the ice, reducing the strain on the anchor. The second was a standard cylindrical buoy 9 feet by 32 feet.

A Discus buoy was designed and constructed in an octagonal shape deployed in the St. Marys River at the Lime Island Turn. The largest buoy tested, the Discus was 16 feet in diameter, but with a shallow draft and with sloping sides so that it too would ride up on the ice surface under heavy pressure.

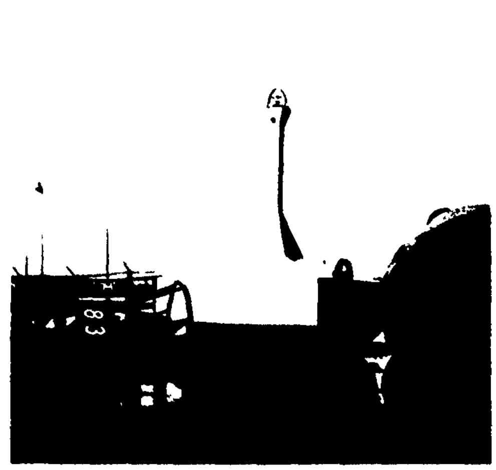
The three large buoys were made with a special anchor system comprised of a high holding power "Stato" anchor, which was capable of producing a holding power to weight ratio of 10:1 and possibly 20:1. With an anchor weight of 9,000 pounds, the holding power could reach 180,000 pounds in the river bottom soils commonly found in the Great Lakes areas. In each mooring chain, self-recording tensiometers were installed to provide data which would determine the ice forces experienced and provide a comparison between different buoy hulls, shapes and sizes.

Three smaller buoys, 5 feet in diameter and 18 feet long, were also tested under ice conditions in the Detroit and St. Clair Rivers, where large sheets of ice do not frequently occur. This would reduce the ice forces on moorings. Instability due to ice accumulation on superstructures was a common problem in these areas, so the modification in the 5-foot by 18-foot buoys attempted to maintain the buoys in an erect position, despite the ice formation.

Additional testing of ice buoys continued in FY 75, with the high hopes that "Stato" anchors and some design modifications of ice buoys would solve problems. Ice accumulation on the top of buoys resulted in the buoy becoming top heavy and turning over, displacing the light from the mariner's plane of eye and damaging the lantern. Also, shifting ice floes in the channel resulted in displacement of buoys, taking them from their charted positions. The tests did not confirm that the revised design solved these problems.



*Experimental ice buoys brought to Great Lakes from Baltic for tests.*



*Octagonal ice buoy.*

User reports indicated that the experimental buoys were generally effective--they maintained their position in ice, were highly detectable on ship radar, readily detectable visually and were a valuable aid to the shipmaster in planning his approach to a turn in the channel. Although the ice conditions were relatively mild during the testing period, the results of these tests indicate that it is possible to design and deploy ice buoys for year-round navigation

While useful in certain areas from the mariner's standpoint, specific lighted ice buoys proved to be less reliable. Generally, unlighted ice buoys showed more promise, and it is expected that there would be more use of this type of buoy in the future as winter aids to navigation in the Great Lakes St. Lawrence Seaway System.

*Deployment and testing of radar transponder beacons (RACONs)*

An evaluation of radar transponder beacons (RACONs) was conducted by the Coast Guard. The RACON is designed to transmit a response to a ship's radar signal, enabling long-range detection of a shore target and better range determining capability

The range enhancement is a significant factor for safe navigation during an extended season because ridges caused by windrowed ice can create a false display of the shoreline, thereby introducing position uncertainties. RACON displays on ship radar screens indicate the bearing and range to the unit and the signal can be coded for positive identification Detection ranges averaged 8 to 16 miles, depending on the type of ship's radar.

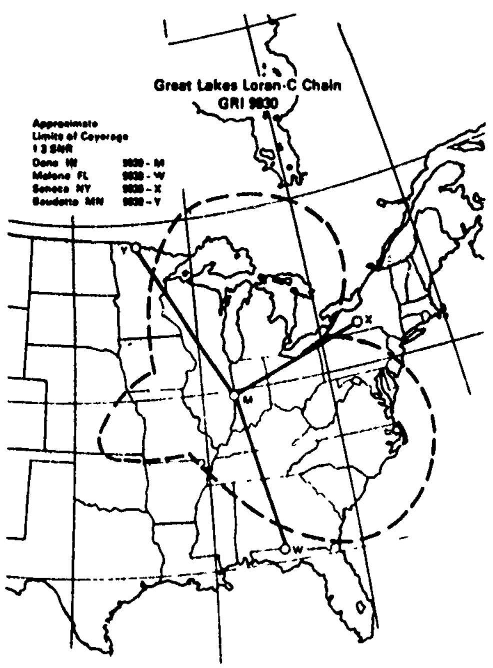
RACON installations in prior years yielded a radar response of 90-150 seconds, which was considered an excessive delay. Modifications to four of the six units were provided to decrease the response time to approximately 30 seconds. The RACONs were deployed at several locations in the St. Marys River.

The RACON response interval is a function of both the rotation speed of the radar antenna and the bandwidth of the radar receiver. Generally, slow rotation speeds (20 RPM or less) and wide bandwidths (12 MHz or higher) improve the detection interval most successfully More frequent response times cause slight decreases in detection ranges for certain ship radars. Despite this decrease, most users favor the shorter interval between responses.

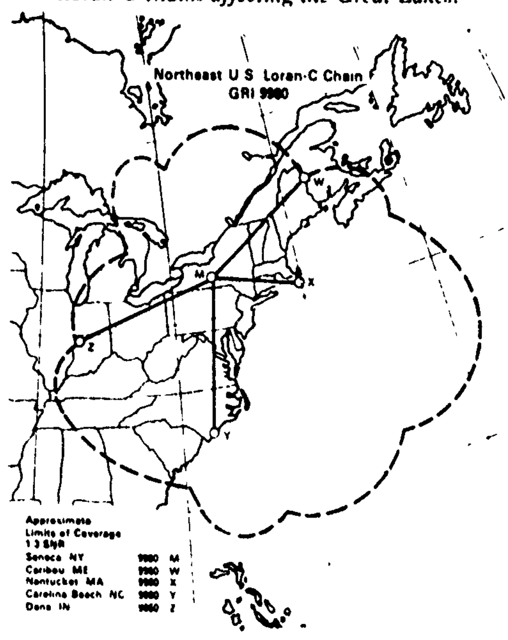
*Mini Loran-C radionavigation system tests*

Loran (Long Range Navigation) is a highly accurate position determining system which utilizes the difference in the time of arrival of radio frequency pulses broadcast by three or more broadcasting stations Simpler to operate than a television set, Loran-C receivers are offering vessel officers position fixing systems capable of determining a vessel's "fix" with accuracy within one-quarter of a mile

A Mini Loran-C, a scaled down Loran-C system involving a low power transmitter, has been installed to provide precision radionavigation coverage of the




*Loran-C chains affecting the Great Lakes.*




St. Marys River. The system consists of unmanned transmitters located from 30 to 100 miles apart which are precisely controlled by a monitor located in the coverage area. The Loran-C coverage area includes the St. Marys River from Whitefish Bay in Lake Superior to DeTour Passage in Lake Huron.

To provide the desired coverage in all areas of the St. Marys River, and to provide the accuracy required for a precision guidance system, four stations (two in Canada and two in the U.S.), are used, each transmitting 100 watts.

Each transmitting station is continuously monitored at the Sault Ste. Marie monitoring station, and is remotely controlled to maintain the required accuracy.

The position accuracy desired in such a system in a region where it is precisely controlled is on the order of $\pm$ 25 feet.

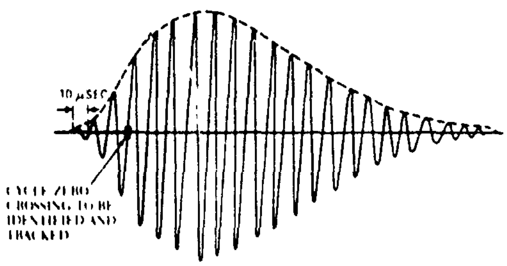
The Mini Loran-C chain is operated and controlled by the U.S. Coast Guard and is officially under evaluation and test status. The demonstration performed at the St. Marys River was to show that a main traffic control system using Loran-C is an effective way to control the passage of vessels through a congested area.

To accomplish that objective, the system must possess a high level of precision necessary to safely navigate in the region and a method of monitoring the progress of vessels in the area from a central location.

In the demonstration system, the precision is shown by processing signals produced by the Mini Loran-C chain and displaying position data on board a vessel, and a remote monitoring function is shown by sending the same position data over a VHF radio link and displaying it on shore. The plot of display on shore, drawing the same track for the vessel as the shipboard plot of display that takes the position data directly from the Loran receiver, provides a real time remote record of the vessel's progress.

The shipboard Loran-C Precision Guidance System was first installed in the fall of 1976 aboard the USCG Cutter *Naugatuck*, a 110-foot tug operating out of Sault Ste. Marie, Michigan. Tests were performed to calibrate the system and check positional accuracy. Additional tests were performed aboard other U.S. Coast Guard vessels and a 767-foot Great Lakes carrier.

During Mini Loran-C demonstrations, it was determined that due to the very narrow channels in the St. Marys River, accuracy within 25 feet is desired. Although this has not yet been achieved, efforts are continuing to find accuracies to these limits. Several changes were made in the graphic display mechanism and mechanical components were made during the program to improve the Loran and its gyrocompass processing.




*Loran-C pulse.*

After the changes the test system was installed on the USCG *Mackinaw* for its winter icebreaking mission. It has shown some ability for providing useful guidance information for navigation in restricted waterways. In addition, the severe vibrations caused by the icebreaking operation of the *Mackinaw* was a good test of the system's mechanical ruggedness.

Additional operational testing is required to fully evaluate the system's navigational capability, ability to follow the same course, and accuracy from end to end of the St. Marys River.

*Precise laser and radar aid to navigation system (PLANS and PRANS) tests*

The Maritime Administration contracted for the study of a precise all-weather navigation system to evaluate several alternative navigation configurations for use in restricted navigation waters.

The objectives of the test program were to acquire engineering data, verify system operation, analyze operational constraints on shipping, and to assemble information pertinent to the specific needs of a Great Lakes all-weather navigation system design. The contract called for the design and construction of a hybrid shipboard radar/laser precise navigation system which would consist primarily of laser and radar transmitter/receivers. A single processing computer, a counter and a display unit were installed on a test vessel. Twenty-nine retro-reflectors and four laser retro-reflectors were installed in 21 locations on the St. Marys River in a 34-mile area adjacent to Sault Ste. Marie to establish the test range, and provide coverage for 12 channels.

The position of the retro-reflectors were accurately surveyed and incorporated into the computer program for the navigation system.

Optical and radio-frequency ranging techniques were utilized, employing both a pulsed laser and a pulsed radar as inputs. A computer, an ultra high speed interval timer and various signal conditioning and control circuits were integrated to provide real time information pertaining to the vessel's position and attitude in the narrow channels. The output displays the distance to the next turn, the distance, right or left of the channel centerline, the angular difference between the vessel's heading and the centerline of the channel and the true speed over the bottom.

Because the accuracy of the laser sub-system had been verified during laboratory testing, efforts were initially concentrated on providing an accurate radar system. During testing of the system problems arose when conditions of poor visibility obscured the laser beams. This required that the radar mode be accurate in order to satisfy the all-weather design of the system. Due to this deficiency, the decision was made to drop the laser mode of the system.

The evaluation of the experimental precise navigation system demonstrated the ability of a computer-controlled system to automatically produce accurate real-time navigational data for a continuous series of courses through restricted waters. Observations indicated that a practical, all-weather, precise navigation system can be produced utilizing a dedicated radar integrated with a mini-computer.

An internal agency decision was made within MARAD not to pursue further developmental work on PRANS until results of the St. Marys River Mini Loran-C chain installation could be judged, because MARAD did not want to duplicate efforts. The Winter Navigation Board did not consider the PRANS system and the Loran-C system competitive. The PRANS activity was transferred to the St. Lawrence Seaway Development Corporation as part of its study entitled, "Definition of All-Weather Navigation Requirements for the St. Lawrence Seaway."

*Development of precise all-weather aid to navigation system (PAWNS)*

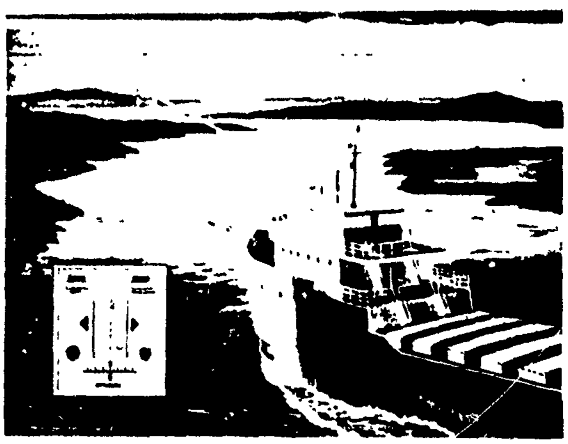
The formation of ice in the St. Lawrence Seaway in late fall necessitates the removal of lighted buoys,

thereby prohibiting navigation during night time and periods of low visibility. To meet the requirement for extension of the navigation season, and to increase the Seaway capacity, the St. Lawrence Seaway Development Corporation has been investigating the feasibility of providing a precise, all-weather, electronic navigation system which will permit operation during periods of darkness and low visibility.

The program is a two-phase study which includes (1) a system engineering study to determine electronic navigation accuracy requirements necessary to maximize Seaway capacity and maintain safety standards and (2) demonstration and evaluation of several electronic navigation systems in the Seaway to determine the applicability of a precise all-weather navigation system to the Seaway.

Two separate system engineering studies were performed and completed during FY 77-78. The first study described the characteristics of the Seaway, identified the high accident areas and established requirements for vessel guidance and navigation within the Seaway. The second study developed the capacity versus electronic navigation aid accuracy relationships for Seaway operations, as well as recommendations for a system specification, which included a data processing and display system.

During FY 79, a navigation demonstration was conducted on the Seaway, using modern electronic navigation equipment. The demonstration facility included a precision reference system, two positioning systems (LORAN-C and RAYDIST-T), and a data display system.



*Precise laser aid to navigation system (PLANS).*

The demonstration data allowed refinement of system performance specifications initially defined in the requirements study. The section of the Seaway between Iroquois and Snell Locks, near Massena, New York, was selected as the demonstration area. System performance was measured with conventional surveying techniques as well as with an electronic precision reference system (Del Norte Trisponder). A data acquisition computer processed signals received from the positioning systems and from the precision reference positioning system for subsequent analysis. The shipboard display graphically provided piloting information obtained from the positioning systems and the ship's gyro. The display, a refinement of the equipment used by the U.S. Coast Guard in the mini LORAN-C tests at the Soo, showed the ship's location, heading and velocity on a computer generated map of the Seaway channel which included shorelines and prominent landmarks. The acquisition system is collecting data which will allow a comparison of the dynamic positions determined by the demonstration systems and the precision positioning system. These data will provide the basis for the statistical evaluation of the demonstration systems.

*Follow-the-wire guidance system*

The Coast Guard investigated a system for ship guidance in channels, harbors and other waterways using a magnetic field generated by undersea cables. The purpose of the investigation was to discover a short-range, high-accuracy system which would be effective under low visibility conditions and would not be affected by high winds and ice. Such a system could substitute under certain limited conditions, for buoys, which are easily damaged at dry dock stations by severe winds and ice.

The wire guidance system consists of an electrical conductor deployed at the bottom of a waterway, along a prescribed course or channel. The water is energized with a low frequency alternating electric current. The magnetic field created around the wire is detectable by using a wire coil. Two such coils are mounted perpendicular to each other and are applied to the vertical and horizontal deflection plates of an oscilloscope, generating an elliptical figure.

The figure on the oscilloscope rotates in accordance with the lateral position of the craft coil with respect to the wire. This phenomenon allows a vessel with a properly installed system to accurately follow the course of the wire installed on the bottom.

*Great Lakes tug assists ore carrier in ice.*

The essential feature of the sensing system was the fact that the vertical component of the magnetic field vanished at points directly above the cable, which was an indication of desired position. The results of the follow-the-wire investigation were sufficiently promising to warrant further investigation leading to a prototype installation.

The Coast Guard performed field trials of a follow-the-wire system. This system consisted of an energized cable which was laid for four miles by the Coast Guard cutter *Woodbine* at the bottom, of the Muskegon Channel, which connects Lake Michigan and Lake Muskegon.

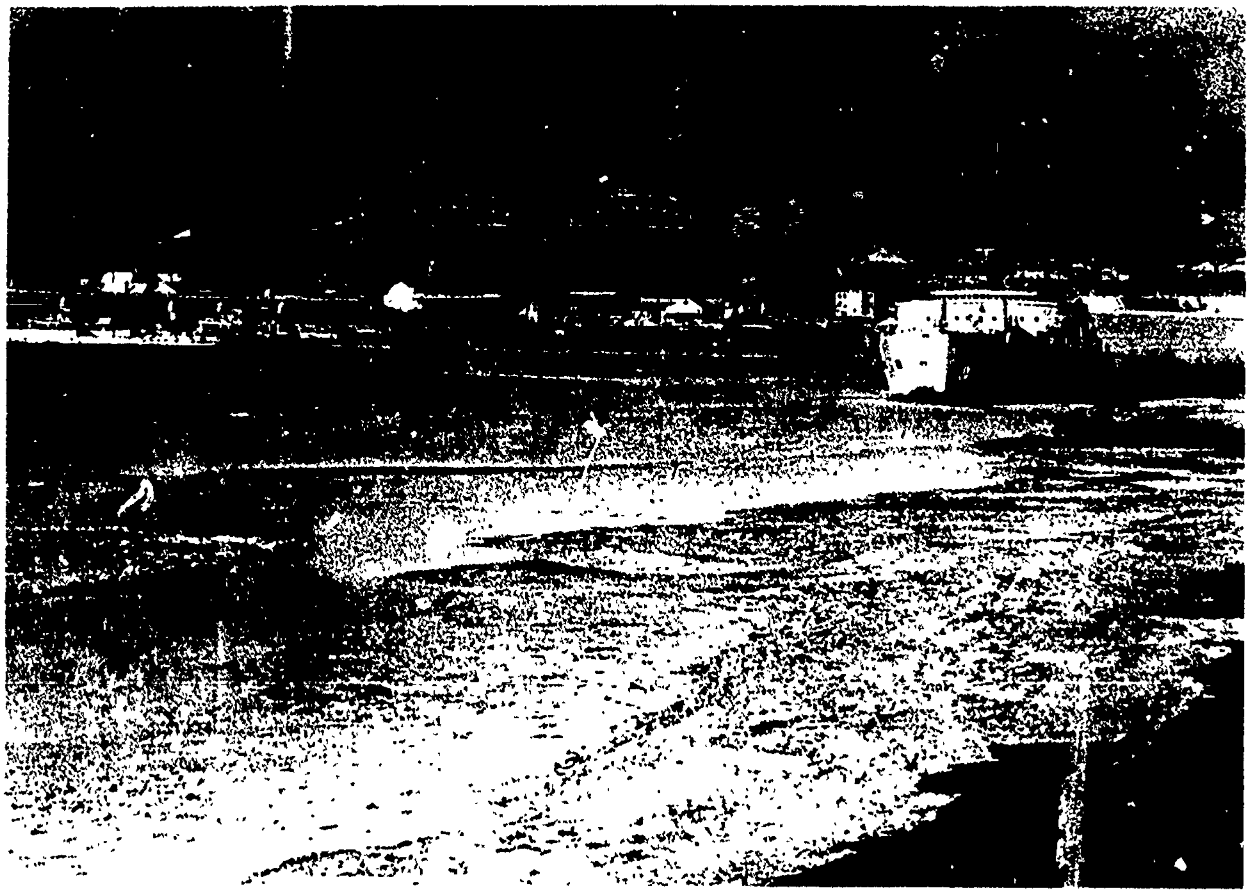
Sensors and display equipment were mounted on the Coast Guard cutter. Results of the field trials again were such as to encourage further investigation of the system.

Under joint sponsorship of the Corps of Engineers and the Coast Guard, a two-step project to design and install a combination air bubbler and wire guidance system was initiated in Whitefish Bay. This particular installation, however, sought to determine the effectiveness of a water bubbler system under shifting ice conditions of larger, open bodies of water. Although a system was designed, it was never tested as it was determined that this system was not as effective as Loran-C and others.

*Laser range light*

The laser range differs from a conventional range light system in that the observer does not have a direct view of the light. A very narrow light beam is aimed above the vessel and is visible due to a scattering of the light beam from minute dust or precipitation particles. The beam appears sometimes like a trolly wire in the sky, providing an accurate lateral alignment of the vessel within the channel. The laser beam could be seen clearly under clear to hazy atmospheric conditions, however, the beam was not used under heavily overcast conditions.

*The* Mackinaw *at work.*



The Coast Guard designed and constructed an experimental single station laser range light consisting of a one million candle power laser and an 8 inch diameter focusing lens. It was installed on Neebish Island to cover Lake Nicolet Channel in the St. Marys River.

The laser range was activated remotely from the Coast Guard base at Sault Ste. Marie. In order to conserve its life, the laser range was used only upon request from a vessel transitting the lower Nicolet west range

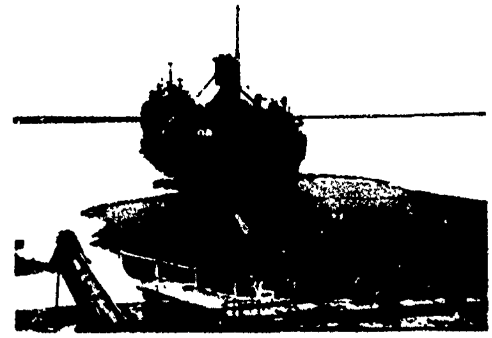
The laser range light was found not to be usable during daylight hours; however, it was extremely visible at night Ship operators reported the system may be too sensitive for mid-channel use. While it was possible to position a vessel under the beam, a person on either bridge wing of a large ship could get the impression that the ship is far off the beam. Further research is required to determine the usefulness of the beam under varying atmospheric conditions and what the optimum requirements of the physical components of the system for all-weather use would be.

### Ice and weather information

*U.S Coast Guard*

*Operation of Ice Navigation Center:* Ice information activities of the U.S. Coast Guard during the Demonstration Program included operation of the Ice Navigation Center, aerial reconnaissance of ice problem areas, and remote sensing of ice conditions on the Great Lakes. Ongoing Coast Guard reconnaissance activities and Ice Navigation Center operations, initiated prior to the Demonstration

*A winter's night in the Straits of Mackinac.*



*Steamer moves through thinning ice.*

Program, were improved under the program. Remote sensing of Great Lakes ice conditions was undertaken as a joint effort by the Coast Guard, National Weather Service, National Aeronautics and Space Administration, and Corps of Engineers.

Established one year prior to the start of the Demonstration Program, the Ice Navigation Center in Cleveland, Ohio, operated seven days a week each year during the ice season. Personnel at the Center kept abreast of commercial shipping itineraries and the plans of all Coast Guard icebreakers. They also scheduled Coast Guard ice reconnaissance, collected and disseminated ice information to interested users, and validated and transmitted remote sensing imagery of Coast Guard shore stations for broadcast to merchant vessels.

The Ice Navigation Center produced an ice summary which was issued approximately three times a week. In addition, the latest ice forecast and outlook issued by the National Weather Service (NWS) were relayed by the Ice Navigation Center for broadcast from Coast Guard shore stations. The ice summary was passed to all teletype-equipped units in the Ninth Coast Guard District and mailed to vessel agents. A high resolution telecopier network enabled the transmission of remote-sensing imagery and ice charts to the NWS Forecast Office, Ann Arbor, Michigan, and Ice Forecasting Central in Ottawa, Ontario, Canada. An information package, containing remote imagery, ice charts, a daily ice summary and wind and temperature charts, was made available to vessels transitting the Soo Locks.

*Ice sampling by Seaway personnel.*

*Frazil ice in Whitefish Bay.*

*Coast Guard helicopter lands on deck of icebreaker*

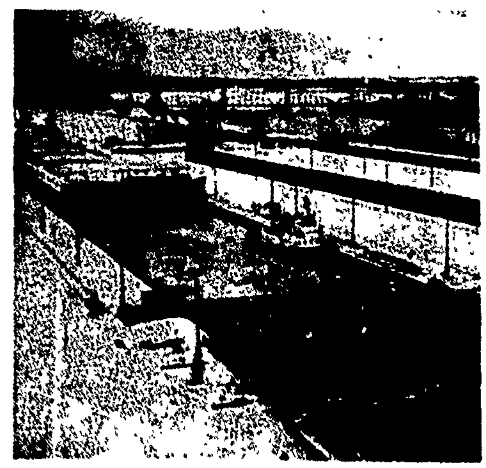
*Aerial reconnaissance and remote sensing of ice conditions.* A system for monitoring ice conditions on the Great Lakes and providing near-real time information about ice location, type and thickness directly to the ships' bridges for winter navigation was developed at the National Aeronautics and Space Administration (NASA) Lewis Research Center at the request of the Winter Navigation Board.

At the heart of the system is a side-looking airborne radar (SLAR) system for detecting ice cover and type regardless of cloud cover. The Coast Guard aircraft flew over the Great Lakes three or four times a week and took radar readings of the size and location of ice cover on the Lakes.

As the aircraft flies over the approximate centerline of the body of water, ice data are taken as continuing data. The data are transmitted in real time through a weather satellite operated by the National Oceanic and Atmospheric Administration (NOAA) to a ground station and relayed via telephone landline to the U.S. Coast Guard Ice Navigation Center at Cleveland, Ohio. The SLAR image is also retransmitted to the NWS Forecast Office in Ann Arbor for use in ice data analysis and forecasting.

Data are then transmitted via a VHF-FM radio link to facsimile recorders on board the ships and in shipping company offices. This process allows the ships and shipping companies to obtain a map of type, location and extent of ice in the entire lake within two to three hours after the aircraft over-flight. With this map, shipping companies can dispatch ships with safe assurance, and ship masters can plot safe and efficient courses.

NOAA weather satellite assistance was also utilized in the Demonstration Program, on a testing basis, to provide ice information. The satellite was part of "Project Ice Warn" by the NASA Research Center at Cleveland. The project coordinated radar readings taken by Coast Guard reconnaissance aircraft with routine satellite weather picture transmissions.



*Ore carrier* Roger Blough *and Coast Guard cutter downbound in Lock at Soo.*

### *Great Lakes Environmental Research Laboratory*

*Ice thickness measurements:* The Great Lakes Environmental Research Laboratory (GLERL), has been collecting data and performing investigations on Great Lakes ice cover since 1963. The purpose of these investigations is to develop, test, and improve methods of forecasting and controlling the effects of ice and snow on navigation, shorelines, shoreline structures, power generation, and the Lakes themselves.

GLERL has utilized surface and aerial reconnaissance to determine ice thickness and movement, and effects on navigation. A component of the National Oceanic and Atmospheric Administration (NOAA), GLERL maintains ice measurement sites along the perimeter of the Great Lakes.

These sites, selected to monitor natural ice growth in early-freezing areas, have been used to record ice thickness measurements for over ten winters at some locations. Ice measurements were made regularly during the extended navigation season program at approximately 35 locations, 11 of which were established as part of the Demonstration Program

*Geologist stores ice sample cut from large field.*

*Geologists cut sections of ice which are then polished and examined with polarized light.*

The actual number of sites varied from winter to winter, depending upon the funding levels and upon the availability of observers. Data from selected sites were coded, tabulated and transmitted to the Coast Guard Ice Navigation Center at Cleveland for operational use at intervals throughout the winter.

*Air and water temperature measurements:* Air and water temperatures constitute two of the basic parameters needed for the development of ice formation and ice deterioration forecasting. Observation of these important parameters at selected river, bay, and harbor locations was initiated during the Winter Navigation Program.

Analog air/water thermographs were installed at two locations on the St. Marys River (Southern West Neebish Rock Cut and DeTour Village) and two locations on the St. Clair River (Algonac and St. Clair, Michigan). These instruments were installed in 1972. Digital punch paper tape water temperature gauges were installed in Duluth Harbor on Lake Superior, in Green Bay and at Grand Traverse Bay on Lake Michigan and Saginaw Bay on Lake Huron in 1974. The thermographs on the St. Marys and St. Clair Rivers were removed in 1976. The digital gauges on the bay and harbor sites are still in operation.

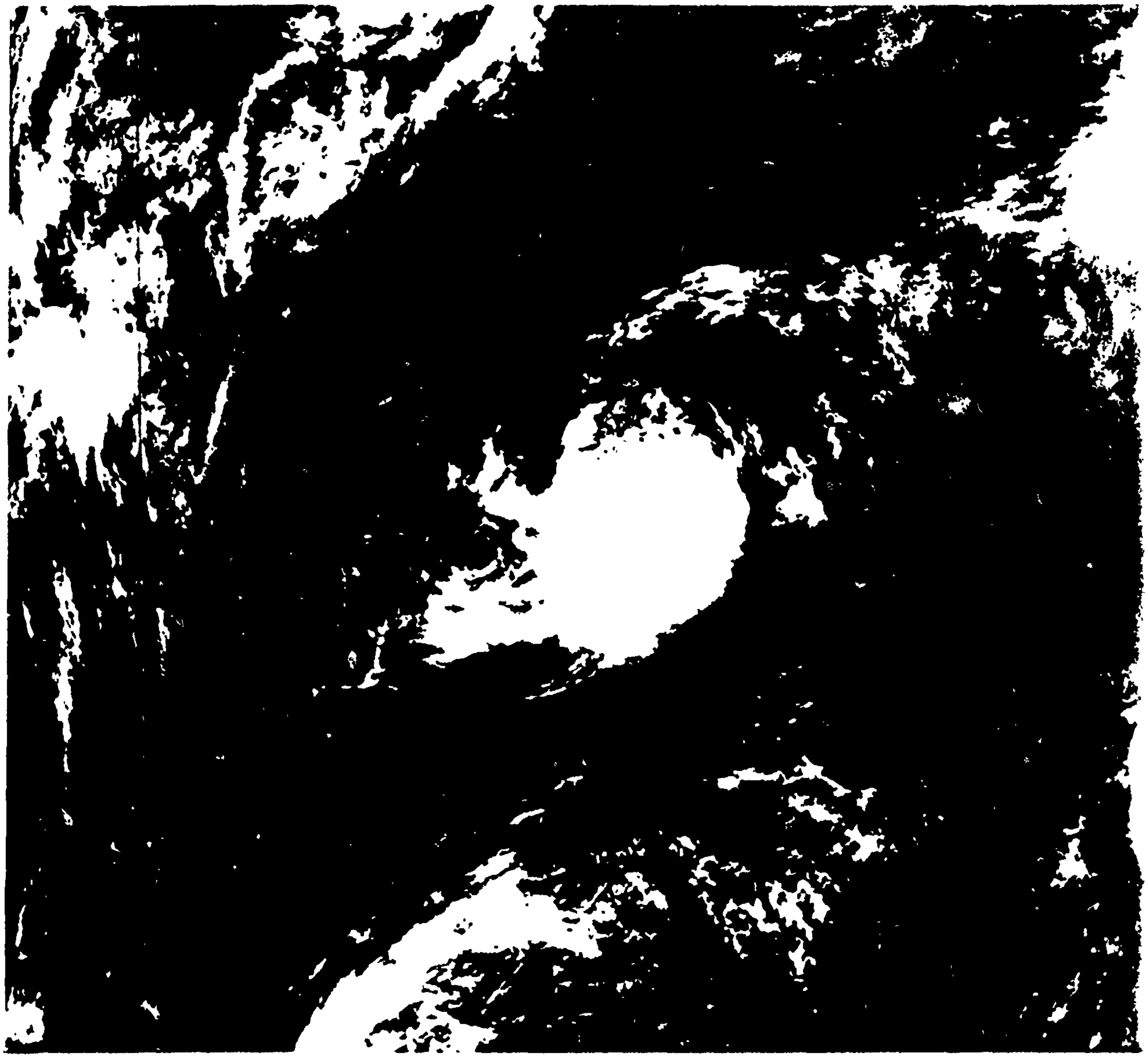
Preliminary analysis of data has been started at all temperature gauge locations, but instrument problems and time constraints have limited the editing of any further analysis of the data. Additional data reduction, editing, and analysis must be performed before evaluations can be made dealing with the application of the data for ice formation and ice deterioration forecasting.

*Bathythermograph measurements:* An important process to consider in the development of short or long range forecasting of ice information for the Great Lakes is the amount of heat stored and its annual variations. Accordingly, in winter 1972-73, a program was initiated to measure heat storage in Lake Superior during the extended navigation season. Preliminary investigations covering 20 cruises over four winters (1972-76) documented heat storage.

Measurements were conducted with an expendable bathythermograph system carried by domestic vessels, which were taking part in the extended season program. After each cruise, data were forwarded to the National Weather Service and the Ice Navigation Center for incorporation in ice forecasts. An assessment of current ice conditions was made.

A four-year program to document fall heat storage in Lake Superior began in 1976. As in the winter program, preliminary field data are made available on a near-real-time basis to the National Weather Service and are used in making operational long-range ice forecasts.

*Development of ice forecasting techniques:* The Great Lakes Environmental Research Laboratory (GLERL) directed research in ice forecasting specifically for the extended navigation program in two areas: the development of freeze-up and break-up forecasts on the St. Lawrence River and the development of special daily ice forecasts for the Little Rapids Cut of the St. Marys River. The ice forecasting techniques developed in the areas were implemented by the National Weather Service.



*Winter storm over Great Lakes as seen from satellite.*

Long range freeze-up forecasts for the St. Lawrence River, based on the procedure developed at GLERL, were initiated by the National Weather Service in the fall of 1975. Operational forecasts of the probability of ice related shore problems in Little Rapids Cut were begun in the 1974-75 winter season. GLERL developed a model to predict the ice breakup period in the St Lawrence River. The ice breakup forecast technique is used to allow advanced scheduling of ocean trade vessels into the system

In addition to the ice forecast study, made specifically for the winter navigation program, GLERL has developed a technique to make long-range predictions of maximum ice extent on each of the Great Lakes GLERL has also developed a technique to make forecasts of ice thickness in a specific river, bay, or harbor location on the Great Lakes. The results of these and other ice forecasting studies are available in National Oceanic and Atmospheric Administration (NOAA) technical memoranda and journal articles.

*Ice build-up on ship.*

*Data collection for St. Lawrence-Eastern Ontario Commission Shore Structure Study.*

*National Weather Service*

*Ice forecasting:* The Weather Service Forecast Office (WSFO) in Ann Arbor, issues ice analyses, forecasts, outlooks, and warnings for all the Lakes and connecting channels above the Welland Canal. WSFO Buffalo is responsible for ice forecasting on Lake Ontario and the upper St. Lawrence River. Buffalo issues a Freeze-up Outlook in early November for the St. Lawrence River below St. Regis Island. Only limited ice forecasting service has been provided for Lake Ontario.

WSFO Chicago also prepares a weather synopsis for the Great Lakes and two hourly storm summary bulletins when conditions warrant.

Teletypewriter messages are transmitted on the Great Lakes Marine Weather Circuit for broadcast by Coast Guard and commercial facilities. Ice charts are sent to the Coast Guard Ice Navigation Center in Cleveland via telecopier and are also disseminated to users by commercial radio-fascimile

The following products issued by WSFO Ann Arbor, cover the winter operating needs for pre-winter and post-winter planning, for short range decision-making, and for long range navigational planning:

Teletypewriter Products -

a. *Freeze-up Outlook.* Issued the 1st and 15th of November and thereafter until general ice cover stabilizes. Departure from normal freeze-up, water temperatures, summary of NWS 30-day weather outlook.

b. *Great Lakes Ice Forecast.* Current weather synopsis and ice conditions plus 24 to 30 hour forecast of winds, temperatures, ice coverages; issued daily at 1600 EST.

c. *Great Lakes Ice Outlook.* Similar to forecast except covers 3 to 5 day periods; issued daily at 1030 EST.

d. *Ice Watch Bulletin.* Issued when necessary to alert users to initial ice formation or expected worsening of conditions over the next several days for key areas.

e. *Ice Warning Bulletin.* Issued when necessary to warn of rapid (24-hour) change in conditions having a significant effect on navigation or when severe conditions are present but not known.

f. *Break-up Outlook.* Issued in early March. Natural vs. icebreaker assisted opening of navigation, temperature outlook, winds, ice deterioration, weather synopsis.

Facsimile Products -

a. *30-day Ice Outlook.* Issued twice monthly starting early November. Portrays schematic percentage of expected ice cover.

b. *90-day Ice Outlook.* Issued December 1. Same information as above.

c. *Ice Analysis.* Issued three times a week in early afternoon. Extent and distribution of ice cover, type, thickness, movement.

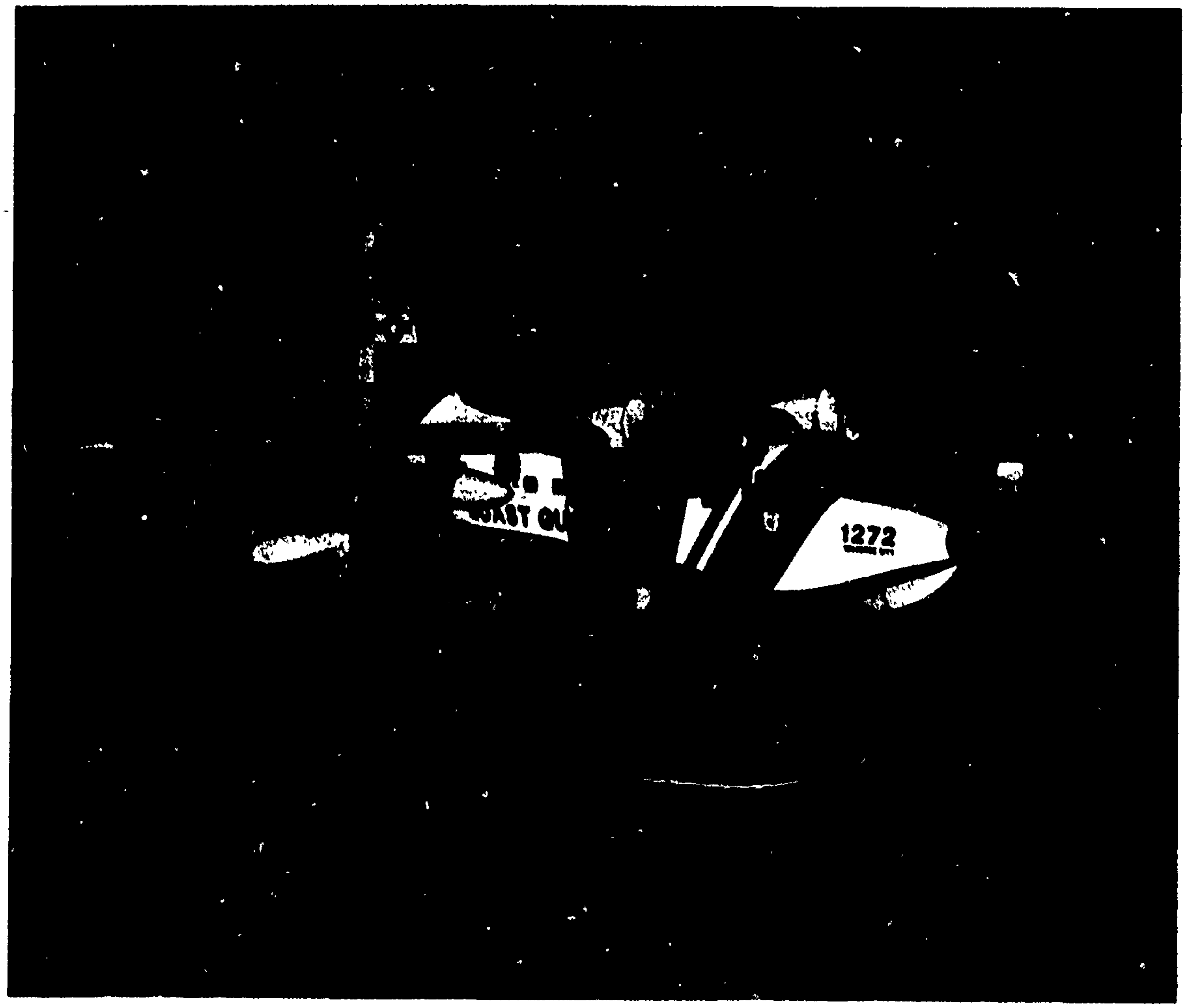
d. *Wind and Temperature Forecast.* 24 and 36 hour charts of isotherms, wind speed and direction, highs, lows and fronts, valid 0700 EST and 1900 EST the following day. Issued daily at noon.

A NWS forecaster was stationed, during the program, at the Coast Guard Ice Navigation Center in Cleveland as liaison with the Ninth District HQ. This individual advises the Coast Guard on weather and ice conditions relative to ice breaker activities; analyzes ice data acquired from ground, satellite and Side Looking Airborne Radar observations; coordinates daily with ice forecasters at WSFO Ann Arbor; and disseminates information to shipping interests.

A major component of the National Weather Service dissemination system for marine services in the Great Lakes is the Great Lakes Marine Weather

Teletypewriter Circuit, created during the Demonstration Program on a test basis, by extending and consolidating several smaller pre-existing systems. This circuit connects all WSFO's, many Weather Service Offices, the Ice Navigation Center, the appropriate offices of Environmental Canada, the Great Lakes Marine Radio-telephone stations and private subscribers. Messages are exchanged year-round between the circuit and the Coast Guard Communications system at the Ice Navigation Center.

Weather observations transmitted on this circuit include (1) ship observations gathered by commercial marine radio telephone stations, (2) observations gathered on the Ninth Coast Guard District communications system, and (3) observations from automatic stations interrogated by NWS offices around the Lakes.




*Coast Guard Albatross photographed above Straits of Mackinac during ice reconnaissance flight*

*Corps of Engineers*

*Ice surveillance:* Ice surveillance activities on the St Marys River, the St Clair-Detroit Rivers System, and the eastern end of Lake Erie, were conducted during the Demonstration Program by the Corps of Engineers

*Winter Navigation Reporting Center:* The Detroit District, Corps of Engineers operated the Winter Navigation Reporting Center for the last three years of the program Daily reports were compiled containing the following information weather conditions in the Great Lakes area, detailed Soo area weather, lockages at the Soo Locks, vessels transiting the St Marys River System, identification of vessels requiring Coast

Guard assistance; ferry operations at Drummond, Sugar and Lime Islands in the St. Marys River and Harsens Island in the St. Clair River; Coast Guard operations on the Great Lakes, i.e., icebreaking assistance; and potential flooding problems due to winter navigation operations.

This information provided an overview of ice conditions on the Great Lakes as well as helping to spot and prevent or alleviate problems with ferry transportation, flooding due to ice jams and vessel movement.

*Ice thickness measurements:* Activities on the St. Marys River included ice thickness measurements throughout the winter at six locations between the Soo Locks and Lake Nicolet. These sites, used for ice measurements since 1968, provide a good measurement for the comparison of ice seasons. Observations were forwarded to the Ice Navigation Center to provide updated information on ice conditions for both the Coast Guard and for commercial vessels.

Ice thickness measurements were taken in conjunction with ice movement measurements at sites between Soo Harbor and DeTour Passage. Marks were placed at measured distances in the ice and monitored for the type and rate of lateral displacement.

Bi-weekly ice thickness and ice characteristic measurements were taken at selected sites in the South Channel of the lower St. Clair River to study ice growth patterns. Ice movement studies were also conducted using dye and wood targets on the ice jam area to determine effects of ship passage.

*Replica of ore carrier moves downbound through main Galop ice boom in St. Lawrence River ice model.*

*The Seaway Corporation's ice breaking tug,* Robinson Bay.

*Corps of Engineers vessel transits ice field.*

*Vesse. moves up track.*

*Time-lapse photography:* Ice formation and movement in the Soo Harbor were monitored by a time-lapse movie camera installed in the 300 foot high Observation Tower that overlooks the Soo Harbor, as well as in a Coast Guard tower upstream of the Sugar Island ferry crossing. This camera provided excellent coverage of ferry crossings at Little Rapids Cut, and documents ice conditions occurring the years before and during the St. Marys River navigation ice boom demonstration.

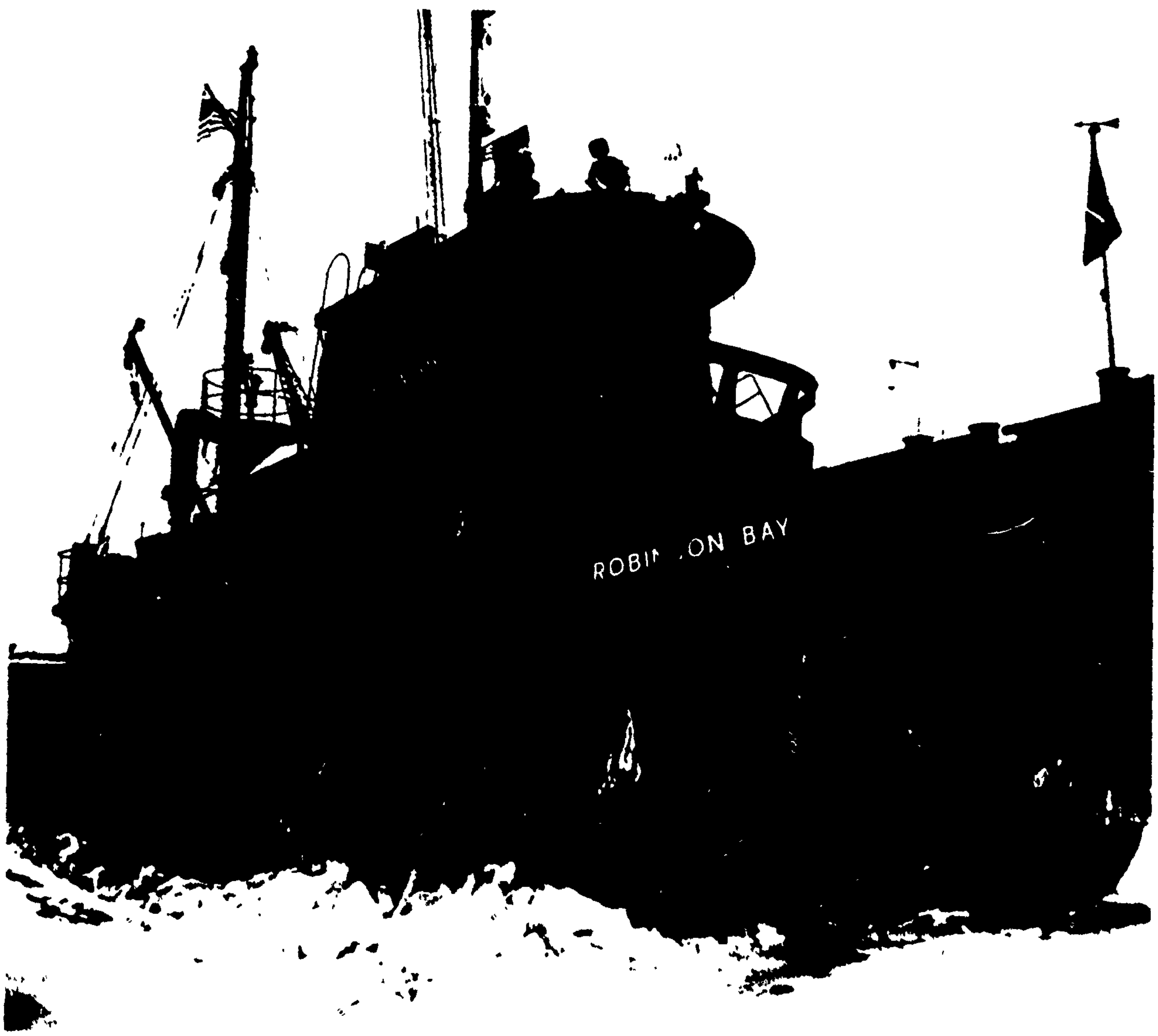
This film record was valuable in determining the amount of ice that bleeds through the navigation gap in the St. Marys River ice boom. Also observed was the effective use of icebreakers to break an ice jam in the Cut that was a threat to ferry operations. Cameras remained in operation throughout the ice season.

A similar camera installation was located at DeTour, Michigan to record ice conditions across DeTour Passage at the Drummond Island ferry crossing, and the possible effect of winter navigation on the area with regard to the ferry crossing site.

Data acquisition and surveillance on the St. Clair-Detroit Rivers System were also conducted during the Demonstration Program. Time-lapse photography was utilized to document ice conditions, particularly the results of vessel passage through the ice bridge in Lake Huron at the head of the St. Clair River.

*Aerial photography:* Aerial photography was utilized to provide documentation of ice conditions on the St. Marys River and to monitor ice conditions in critical areas of the navigation channel. Regularly scheduled flights were flown in support of Corps of Engineer's ice surveillance activities on the St. Marys River. The project has proved to be one of the best means for documenting ice conditions, ice fractures, and ice problem areas over the entire river system.

Aerial photography was also used to survey and document ice conditions in critical areas throughout the Great Lakes-St. Lawrence Seaway System. Ice charts of ice coverage in the system between Lake Huron and Lake Erie were prepared.



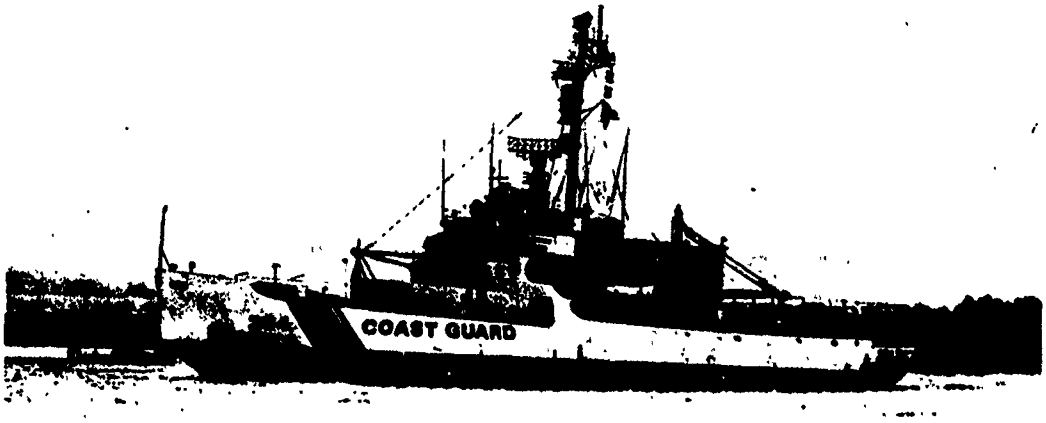

*St. Lawrence Seaway Development Corporation*

*Ice surveillance and monitoring of St. Lawrence River:* The St. Lawrence River ice and weather data collection program began in the fall of 1971 and has continued throughout the program. It has comprised the application of a wide range of available techniques for documentation of winter conditions as well as the development of modified techniques to address special problems. The program was directed toward filling data gaps and complementing the data collection efforts of other agencies.

Ice coverage was documented by vertical aerial photography flown on approximately one week intervals, with more frequent coverage during the ice formation and break-up periods. This coverage was supplemented by aerial reconnaissance and oblique aerial photography, as well as by time-lapse photography in selected locations.

A limited program of ice thickness measurements was undertaken to supplement the extensive network of ice measurements taken each winter by the Canadian St. Lawrence Seaway Authority. Radar and manual profiling of the ice in the Cardinal to Wad-

*The* Edisto *is shown upbound at Sugar Island Ferry lane at Little Rapids Cut during 1972 demonstration tests.*




dington area was accomplished to document the hanging dams which occur in that reach of the River.

An ice marking and monitoring study was performed to refine techniques for monitoring ice movement. These were utilized in the Copeland Cut test boom project and at Ogden Island.

Recording and telemetering thermographs were installed at three locations to provide input data for navigation season closing decisions and for support of ice forecasting activities. Two supplemental automatic weather stations were installed in cooperation with the National Oceanic and Atmospheric Administration-Great Lakes Environmental Research Laboratory (NOAA-GLERL) to provide data on the climate at the river.

A shore erosion/shore structure damage monitoring program was carried out for the final four years of the program. The U.S. shoreline was mapped, and shoreline and structures were classified in terms of the potential for ice impacts. Selected structures and erosion-prone areas were monitored photographically and with surveying equipment to provide baseline data on natural ice impacts.

## Safety/survival

### *Survival equipment development and tests*

Attempts to assess the adequacy of shipboard escape and survival systems, and to identify areas where improvements are needed, were initiated by the Coast Guard at the request of the Winter Navigation Board. Initial efforts were made in the direction of a systematic study to define the problems and to investigate the effectiveness of various solutions.

The primary areas of survival investigation included individual exposure protection, group exposure protection, distress, alert and detection enhancement, and an overboard alarm system.

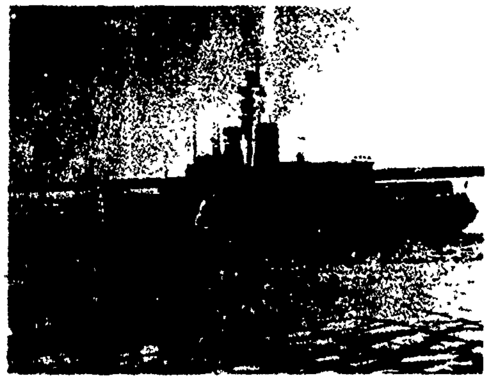
Investigations included a prototype constant exposure jacket (developed by the Naval Air Development Center), an enclosed survival module, and the determination of survival times in cold water while wearing typical seaman's winter clothing.

A private laboratory was contracted by the Coast Guard to study the requirements for survival on the Great Lakes and to evaluate the application of survival suits to crew survival.

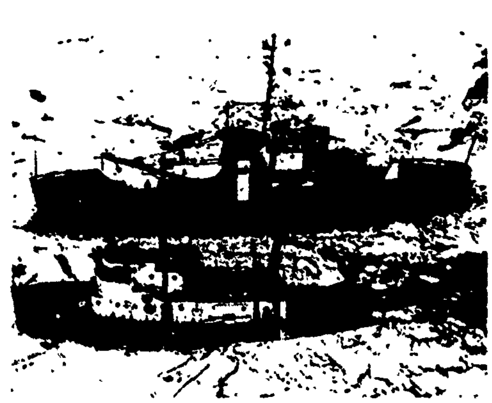
The study was designed to produce four outputs: (1) the environmental conditions which must be satisfied in the design of any survival system or equipment; (2) the functional or performance requirements which must be satisfied by such survival systems and equipment; (3) test plans for the evaluation of survival systems and equipment; and, (4) identify areas where inadequacies exist and additional development and research efforts are needed.

Through the use of simulation and computer models, specific requirements were established. The problem of immersion hypothermia (lowered body temperature) to Great Lakes casualty victims and the lack of a suitable alternate to the use of exposure suits, led to the investigation of the life saving potential of existing and specially designed personnel exposure suits.

Survival time due to exposure to cold was determined. For the normal range of temperatures of lake



*The* Westwind *at work during the program.*



*The* Ojibwa *is foreground with* Mariposa.

water (32° - 55° F), these time are quite short. In 32° - 33° F water, the expected time of survival without special protection in water is from 15 to 45 minutes. In 40° - 50° F water the range is from one to three hours. The initial shock via entry often incapacitates many victims.

In the study, hazards were identified and solutions were evaluated including the evaluation of a variety of commercially available suits. Two suits which are commercially available appeared suitable for use in that they provided complete coverage for the body and extremities, leaving only the face exposed. Some 280 exposure suits were distributed to vessel crews participating in the extended season activity.

Information describing the latest techniques for cold water survival has been published and distributed to crew members of vessels engaged in winter navigation.

*Detection tests*

Activities in detection enhancement included an exercise in which Coast Guard personnel were set adrift on a raft in Lake Huron. This demonstration successfully utilized radar transponders and other equipment. Emergency Position Indicating Radio Beacons (EPIRB's) were also extensively tested.

A "Man Overboard Detection and Location System" was undertaken by the Coast Guard. A feasibility study indicated that there were several systems that could be initiated. The system that appeared to function best was developed into a prototype. Under the system evaluated, each person on a vessel would wear a radio transmitter with a self-contained antenna which would begin to operate automatically by means of a water activated switch whenever the wearer entered the water. A special receiver on the bridge of the vessel would sound an alarm when the signal was received. The transmitter signal then could be used as a homing device to locate the person in the water.

*Safety/survival equipment wintertime training*

Training in the use of safety/survival equipment is the continuing responsibility of the vessel owner and the master.

The Maritime Administration's Great Lakes Region Office, requested to assess these training needs, communicated with major lakeship operators, seafaring unions, pilots' associations, mining companies, Great Lakes shipping associates and other Federal agencies. These groups were asked to provide comments and recommendations relevant to a viable assessment of pilot/masters training needs. The questions that were posed to survey recipients were direct, simply presented and to the point. They were: Is this training essential and valuable? When should we undertake an administrative program? Who should participate in this training phase? Would you

*Soo Locks.*

support this program? How should these classes be funded? What do you consider an adequate training period?

Response to the survey indicated a consensus in favor of a continuation of "on the job" training in order for operators to provide qualified and competent masters and pilots to man vessels during the extended navigation season.

*Communication tests*

The high level VHF-FM communications system has been developed and is in current use by the Coast Guard throughout the Great Lakes.

## Levels and flows

*St. Marys River*

A series of water level gauges were installed between Soo Harbor at Sault Ste. Marie, Michigan and Ontario and the lower end of West Neebish Channel and were monitored by telephone or visual inspections each day and subsequently plotted to form a hydrograph. The purpose of this activity was to aid in the early detection of ice jams as well as to study the effects of wind and/or ship passage on lower levels. Because ice jam blockage can be monitored as upstream levels rise, the opportunity develops to provide flood alerts or break up the ice jam

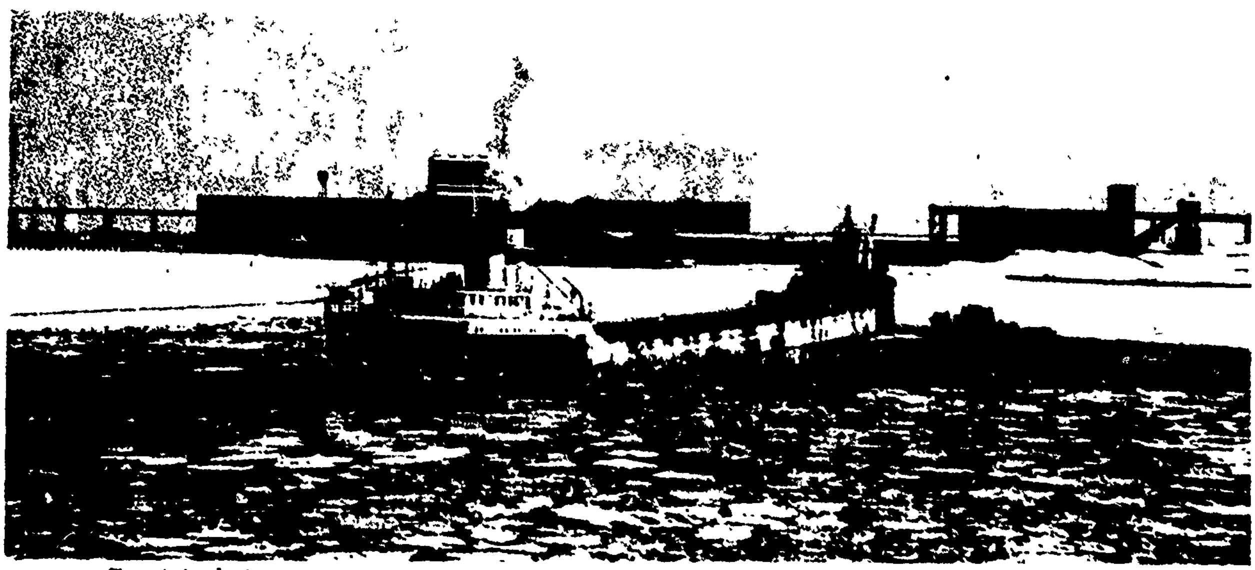
A study was undertaken on the St. Marys River to help stabilize the ice cover in Soo Harbor and to reduce the volume of ice that entered the Little Rapids Cut. A hydraulic scale model of the harbor and upper channels around Sugar Island was designed and constructed to duplicate existing flow patterns and ice conditions.

Baseline data utilized aerial photos, time-lapse photos, ice thickness measurements, water level hydrographs and meteorological data. Flow pattern studies and other hydrological data were collected as needed to aid in the model calibration. The model was utilized in testing various ice boom arrangements and other ice stabilizing concepts that would permit ship movement and still allow for stable harbor ice.

Flow discharge measurements were taken in the St. Marys River in two channels around Sugar Island to detect the effect of ice jams on flow distribution, and an operational plan to reduce flood risk was developed and issued to all participating agencies.

Two ice booms with a 250 foot navigation opening between them were installed at the outlet of the harbor to stabilize the ice flow in the harbor during the winter of 1975-76. The location and lengths of the booms had been determined previously by the model tests described above. Forces in the upstream end of the ice boom structure were monitored throughout the winter by six underwater sensors, three in each boom. Forces were recorded and supplemental data on ship passages, ice conditions, meteorological conditions, water flow and water levels were also taken.

The booms proved to be highly effective in retaining broken ice in the harbor while allowing ships to transit. The booms on both sides stabilized the ice field



*Transit in the ice.*

and prevented it from drifting and jamming into the Little Rapids Cut.

Occasionally, the ice sheet between the navigation channel and the U.S shoreline would break away and pivot or override the west boom, causing high stress in the boom cable. Strain gauges attached to the cable monitored the stress, which was reported on a strip chart recorder located in a heated shelter near the boom installation. On-site observers helped differentiate between natural and ship-induced effects.

Temporary rock-filled structures, which were installed upstream of the west boom to prevent the ice sheet from pivoting away from the shoreline and loading the west boom were quite effective.

The value of ice booms and rock filled structures has been demonstrated: since these structures were installed, there have been no major disruptions to ferry service due to ice backup as previously experienced.

Field investigations and photography were effective in determining and documenting data on movement of ice. Additionally, they were used to distinguish between ice movement related to ship transits as opposed to ice movement caused by natural conditions. Field data such as ice thickness measurements, and meteorological data were provided to the Ice Navigation Center for their forecasting use.

*St. Clair-Detroit Rivers System*

As part of the Detroit District Corps of Engineers ongoing activities a data collection program was operated in this system to observe and document ice and water level conditions during each year of the Demonstration Program.

Water levels were monitored at strategic locations along both the St. Clair and Detroit Rivers. Levels were plotted at three hour intervals along with pertinent wind, ice, temperature, and ship-related data to better interpret the effects of water level change. Water levels at key gauge locations were also monitored several times each day via telephone-reporting gauges and plotted for early detection of ice jams.

When ice jams were detected (by observing the rise in upstream levels and the lowering of levels downstream of the jam), the National Weather Service and the U.S. Coast Guard were notified of potential flood conditions.

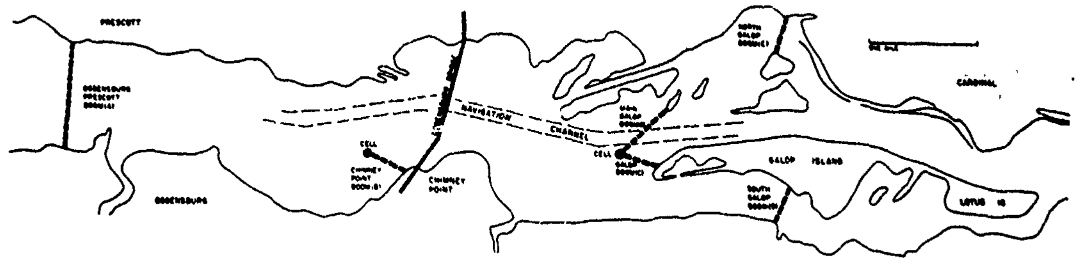
A plan of action was developed for each river that involved the close monitoring of levels and ice conditions via aerial and ground observations. More serious jams required icebreaker passage through the jam area in an attempt to break up the ice constriction

Weekly aerial photographs were taken of the St. Clair-Detroit Rivers System to document the changing ice conditions and patterns in order to better interpret the effect of ice on levels, flows, and restrictions to winter navigation.

A time-lapse movie camera was installed each winter in the Fort Gratiot Lighthouse to document the volume of broken ice that enters the St. Clair River. In addition, it recorded the periodic formation, breakup, and effect of ship passage through the ice arch (bridge) that forms across the river entrance.

Natural wind action and vessel movement at the head of the St Clair River has disrupted the stable ice bridge which forms above the entrance to the river. A two part model study is being performed to determine the most effective type and location of an ice control

*Location of ice booms, Ogdensburg-Prescott area of St. Lawrence River.*




structure to be placed in that location in order to stabilize the ice cover.

The model study includes a hydraulic study and a wind stress study. The models have been designed, built, and calibrated based on actual field data collected in the area. The model study is scheduled to be completed in the latter part of 1979.

A contingency plan was developed for each river involving close observation of changing levels and existing ice conditions Close liason was maintained with the Coast Guard and National Weather Service to analyze imminent problems and decide upon the best course of action to reduce any flood threats.

*St. Lawrence River*

Substantial improvements in the existing ice control systems in the St. Lawrence River will be required before any significant extension of the navigation season is possible Required Canadian improvements are being addressed by the St. Lawrence Seaway Authority of Canada. In the International portion of the river, the major required improvements are in the International Rapids Section, between Ogdensburg and Waddington, New York.

Initial efforts by the St. Lawrence Seaway Development Corporation's (SLSDC) program in the first two years of the program were directed at installing and testing a movable gate in the Ogdensburg-Prescott ice boom, which crosses the navigation channel. Concerns of the power entities precluded anything but open water testing of this modification.

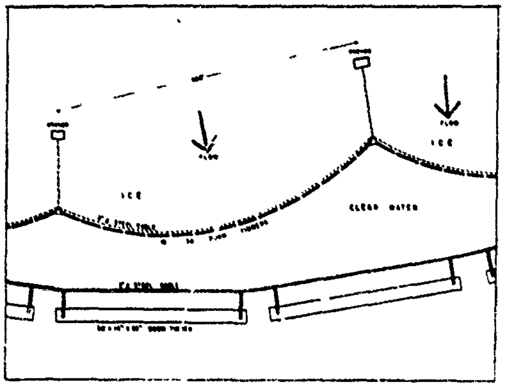
At the same time, SLSDC contracted for a systems analysis of St. Lawrence River season extension. This study, entitled System Plan for All-Year Navigation (SPAN) identified constraints to extended season navigation between Montreal and Lake Ontario and proposed three levels of alternatives for removing those constraints, in 15 weekly increments, to permit navigation.

It also provided a benefit/cost analysis for each of the 45 alternatives examined. The study addressed the need, in addition to ice control improvements, for a precise all-weather navigation system, for vessel capability criteria, for icebreaking and special channel clearing devices, and for improvements at the locks. SPAN provided the basis for focusing subsequent demonstration activities.

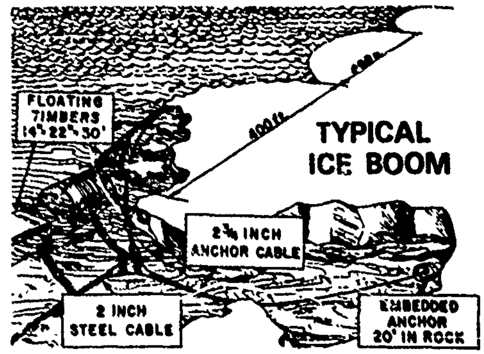
Following these efforts, a demonstration ice boom for extended season navigation was designed for the Ogden Island area. As a result of input from other agencies, the decision was made to transfer the test to the Copeland Cut area of Lake St. Lawrence on the Wiley-Dondero Canal just above Massena, New York. This study, completed in 1975, demonstrated the technical feasibility of maintaining a stable ice cover behind a boom while navigating through it.

The focus then shifted back to a demonstration of the feasibility of commercial navigation through the booms, which the power entities install across the

*Sketch of ice booms in position.*



*Sketch shows ice boom construction.*




navigation channel at Ogdensburg-Prescott and Galop Island. This was accomplished in a phased hydraulic/ice model/design effort which first calibrated the technique for modeling ice boom loads in undistorted and distorted scale models of the Copeland Cut test boom. The next study was done on the Stillwells Point to Red Mills, New York, reach of the river, in which the power entity booms are installed. The study report entitled the 1978 "St. Lawrence River Ice Boom Modification Study," presented the results of improving the existing ice booms in the International portion of the St. Lawrence River to provide for extended season navigation. The study objective was to assess the impact of ships navigating through the river in the winter on the regulation of Lake Ontario outflows and the environment along the river. The study concluded that the Ogdensburg-Prescott and Main Galop Booms can be modified to permit winter ship transits, that they will maintain the stability of the ice cover behind these booms, and that they will have negligible impact on the levels and flows of the St. Lawrence River, Lake Ontario, and power production at the Moses-Saunders power dam. This effort resulted in designs for a proposed ice boom demonstration and in designs for an ice control system which would allow all-year navigation in this reach of the river.

The actual demonstration, involving a modification of Galop and Ogdensburg-Prescott ice booms to provide an opening through which limited vessel transits could take place, did not occur. This was due to strong environmental objections by the State of New York and limited time constraints of the Demonstration Program authorization. Additional controversy arose as to the projected effects of such a test on the levels of Lake Ontario and flows associated with the St. Lawrence River. Theoretical mathematical studies were performed by the Corps of Engineers, the New York Department of Environmental Conservation and the St. Lawrence Seaway Development Corporation. These three studies yielded varying results.

An additional study was then undertaken by the Corps of Engineers to: (1) describe in detail each of the previous methods analyzed to compute impacts; and (2) establish and coordinate a set of criteria and parameters for the test and compute, using those criteria, a best estimate of the expected impacts on levels and flows.

Based on the results of the study, it was concluded that the St. Lawrence River ice boom demonstration would have no impact on the water levels of Lake Ontario, no impacts on the flows of the St. Lawrence River, and would not reduce the average water level of Lake St. Lawrence by more than approximately one-half foot. It was also concluded that these results were conservative because of the data (excessive ice release volume per ship passage) used in the analysis.

The State of New York maintained its position that any impacts occurring were unacceptable, and claimed that the state-of-the-art of mathematical models was not developed to an extent that accurate predictions could be made.

## Navigation locks

*Methods to remove ice from lock walls*

Removal of the ice collar, a buildup of ice on the lock walls caused by frequent lowering and raising of the lock water levels, has been approached in two ways: (1) mechanically cutting the ice collar or (2) chemically coating the lock walls to reduce the ice adhesion force so that removal can be facilitated.

An ice-cutting saw has been developed and is now operational. The unit consists of a 15 foot bar and chain cutter similar to that used in the coal industry. The cutter is mounted on and driven by a four wheel drive tractor. Traverse speeds of over 10 feet per minute can be steadily maintained while cutting through ice collars 2 feet in width and 6 to 8 feet deep. The ice cutting saw was used at the Poe Lock at Sault Ste. Marie, Michigan, during the winter navigation season.

*Tests to prevent ice build-up on lock walls*

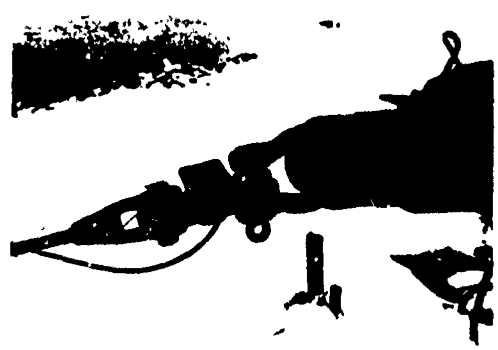
The chemical coating to reduce ice adhesion forces is a copolymer compound consisting of polycarbonate and polysiloxane. The copolymer can be sprayed onto a clean surface, leaving a thin, clear, pliable film. Trial tests during the 1976-77 winter season were very promising, in that the time and effort required for ice collar removal using both mechanical means and steam was reduced.

An epoxy resin undercoating was used before applying the copolymer. Presently, the entire Poe Lock, from high pool level to 10 feet below has been coated with the epoxy undercoat.

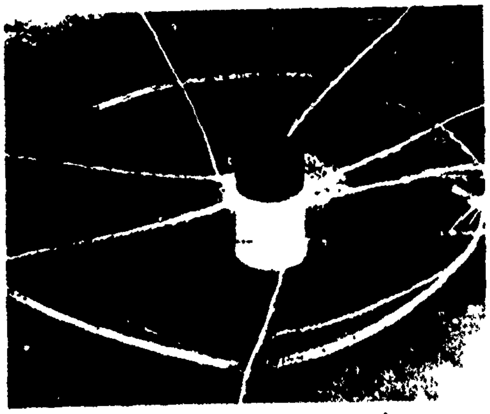
Other methods that have been tested to remove the ice collar from lock walls included a scraper blade mounted on the bow of a Corps of Engineers' tug, removal using a tractor mounted backhoe unit, a flexible lock wall panel, high pressure water jets, and the use of steam.

Of various methods tested to remove the ice collar from lock walls, the use of steamlines and hoses has proved to be most effective. This technique was particularly effective in conjunction with use of lock wall

*Backhoe scrapes ice off lock walls.*



*Strain gauge attached to ice boom anchor.*



*CRREL's laboratory pile tests with fresh ice cover*

*Steel anchors being fabricated for ice boom gates anchor.*

coating chemicals. While the chemical coating did not prevent ice from forming on the walls, it did reduce removal time and decrease effort when used with other methods of ice removal.

*Tests to prevent ice from entering lock chamber*

Experiments to retard ice formation behind lock gate recesses involved heat cables and air-bubbler lines. The air-bubbler system was utilized also to flush ice from behind lock gates and to reduce ice buildup on approach walls. A bubbler line was also tested across the upstream approach to the lock. The line produced a flow pattern which pushed loose ice aside, allowing ships to pass through the lock chamber without pushing large quantities of ice ahead of them into the lock. Such a system was installed at Snell Lock in 1975, at Cote St. Catherine locks in 1976 and above the Poe Lock at Sault Ste. Marie, Michigan in 1977.

Lock operating personnel, well satisfied with the operation of the high flow air stream, noted these benefits: ease of gate operations with less time loss in opening and closing of gates; less delay in ship lockage; and less time and effort required removing ice buildup from lock walls.

Heating cables have been effectively used in lock gate machinery recesses to prevent ice buildup. Air-bubbler lines along the lock floor chamber have been effective in retarding ice formation and also for flushing ice from the lock gate recesses.

## The environment

The concurrent conduct of a Demonstration Program and a Survey Study resulted in confusion from an environmental point of view because of the radically different perception of the potential environmental effects of a short-duration demonstration activity and of a long-duration operational program. While the demonstration program, by its nature, could not resolve or settle all of the potential environmental problems, it did surface a diverse array which must be addressed in future years.

*Environmental Evaluation Work Group activities*

The U.S. Environmental Protection Agency was the lead agency and Chairman of the Environmental Evaluation Work Group. Other agencies represented included the U.S. Army Corps of Engineers, U.S. Coast Guard, U.S. Fish and Wildlife Service, National Oceanic and Atmospheric Administration, Maritime Administration, and St. Lawrence Seaway Development Corporation. The work group also included state representatives from the eight Great Lakes states, an observer from the Canada Centre for Inland Waters, and the Midwest Representative of the Sierra Club.

Work group activities centered primarily upon the evaluation of environmental effects of specific demonstration projects that involved physical contact or interaction with the environment.

The environmental effects of these types of projects were first assessed by the individual work groups responsible for each project. Supervision and guidance on the data needs, methods of evaluation, and preparation of the environmental assessments were then provided to the Environmental Evaluation Work Group. Evaluations of each project were subsequently made by the agencies represented on the Environmental Evaluation Work Group.

Some of the information submitted by the participating agencies, while not specifically related to a particular demonstration project area, applied to environmental considerations for the navigation season extension over the entire Great Lakes-St. Lawrence Seaway System.

Evaluations were made according to the agency's area of expertise. In addition, both the Heritage Conservation and Recreation Service and the U.S. Fish and Wildlife Service accumulated a limited amount of baseline data covering the Great Lakes concerning their respective areas of expertise. These studies included gathering information on the location of wildlife habitats, waterfowl feeding and nesting areas, and areas of fishing activities on the Great Lakes.

A significant part of the Demonstration Program involved activities such as ice surveillance and basic data collection in which no physical interaction with the environment occurred and as such required no special environmental studies.

Activities evaluated included the bubbler-flusher system at the mainland dock of the Sugar Island ferry crossing, the Lime Island Turn air bubbler system in the St. Marys River, the Duluth-Superior Harbor air bubbler system installed near the entrance of Superior Harbor, the Howards Bay (Duluth-Superior Harbor) air bubbler system, the ice boom gate installed in the Ogdensburg-Prescott ice boom, and the Copeland Cut test ice boom. In addition, a thermal ice suppression test was conducted in Saginaw Bay in Lake Huron and an ice navigation boom in the St. Marys River was tested.

An environmental assessment for the St. Lawrence River Demonstration activities was prepared, and a monitoring program to define the environmental effects of the Demonstration activities was developed.

There were potential problems with respect to bubbler systems, effects on shore structures, shore erosion, and creation of waves under ice. Results of studies to date indicate that winter vessel movement in certain channels and narrow passages have caused an increased rate of shore structure damage, but are believed to have a minimal effect on shoreline erosion. Large vessels, passing at maximum allowable speeds, create drawdown conditions which break the ice-cover, and the resultant ice action creates damages.

In accordance with the National Environmental Policy Act of 1969, an Environmental Impact Statement on demonstration activities was filed with the Council on Environmental Quality for every fiscal year from FY 74 through FY 79. These statements, prepared by the U.S. Army Corps of Engineers, were filed prior to the start of each season and provided the basis for comparison of the anticipated and actual impacts of each activity.

In addition to these statements, the U.S. Coast Guard prepared an Environmental Impact Statement on its on-going icebreaking activities related to its statutory responsibilities.

Special studies conducted by the Environmental Evaluation Work Group included a study of the effects of winter navigation on outdoor recreation on the St. Marys River, a long-line air bubbler fish study, pressure wave measurements, and a study of turbulence effects on shallow water sediments and organisms, macrobenthos study on the St. Clair River, and preliminary evaluation of demonstration activities on the St. Lawrence River.

*Environmental Impact Statements*

Environmental Impact Statements for individual activities have been prepared during each year of the Demonstration Program. The yearly reports identify the participants in the tests, describe the demonstra-

*Ice in Lake Superior.*

tion activity, the environmental setting without the project, and the environmental impact of the activity. Included are remedial, protective, and suggested mitigating measures.

Applicable environmental data obtained during the Demonstration Program is being used for preparation of an Environmental Statement which will accompany the Winter Navigation Survey Report.

*Environmental data collection during air bubbler operation*

An environmental study was conducted to determine the effects of a harbor air bubbler system on the water quality of Howards Bay in Duluth-Superior Harbor during the winters of 1973-74 and 1974-75. The areas of study involved water temperature, conductivity, water samples for chemical analysis and oxygen content, and the effect of ambient temperature. No adverse effects were identified during the demonstration period.

*Monitored fish movement at proposed air-bubbler location*

The Environmental Evaluation Work Group, through the U S. Fish and Wildlife Service, negotiated a contract with the Lake Superior State College, Sault Ste Marie, Michigan, to study fish movement in a shipping channel in the St Marys River. In addition to gaining fish movement information, the study was to provide information on species composition and the

relative abundance of economically important fish in the St. Marys River. The study was to collect fish movement data throughout most of the 1974-75 winter season.

The study area was located in the West Neebish Channel above the Rock Cut, some 21 miles south of Sault Ste. Marie in the downbound navigational channel of the St. Marys River near Barbeau, Michigan. This area was selected principally because it is traditionally closed to navigation after 15 December.

That winter happened to be one of the mildest since the beginning of the Demonstration Program and, as a consequence, the entire study had to be completed within 12 days in March.

Two model 115 Vexilar Sonagraphs were placed in a specially constructed ice shanty to record fish movements from 5 March through 16 March 1975. A timer was constructed to run the instruments for six minute periods alternating with 12 minutes of inactivity. The recording paper was changed at least once a day, usually about 1700 hours. Three records were made with a transducer pointed straight down to determine swimming depth of the fish. For the remainder of the study the transducers were angled downwards, one to the north, the other to the east.

Attempts were made to identify fish with the use of gill nets in November 1974 and March 1975 but these proved ineffectual.

The monitoring of fish movement at a site in the St. Marys River was limited in scope because the effective range of sonar devices employed was small and because climatic conditions did not permit time to monitor the movement patterns of fish at other locations. The study did result in the collection of viable data, however, regarding fish activity near a navigation channel during the winter season.

*Environmental data collection at Saginaw Bay thermal ice suppression test.*

An environmental evaluation study of the thermal ice suppression demonstration project in Saginaw Bay was requested by the Environmental Evaluation Work Group

The Great Lakes Fishery Laboratory of the U.S. Fish and Wildlife Service contracted to conduct the evaluation The study period began in 1972 and ran to 1976. Its primary objective was to collect appropriate biological data in order to evaluate the effects of the thermal release on seasonal abundance and species composition of fish and benthic organisms in the area that would be influenced by the project. Benthic

*Air-water thermograph in the St. Marys River.*

macro-invertebrates were selected because of their importance to the fishery, their relatively low mobility and stable community structure, and their high sensitivity to environmental changes.

Emphasis was placed on yellow perch because of the high fishery value of this species in Saginaw Bay and because a previous EPA study suggested that exposure of adult perch to elevated winter water temperatures could adversely affect their production of eggs and fry. Benthic invertebrates were sampled during ice-free periods before and after the demonstration of the thermal ice suppressor. Fish were sampled before, during and after the release of heated water.

A sample of 18 species of benthos was taken in the study area, consisting primarily of oligochaetes and chironomids. These were the only two that could be treated statistically. A total of 27 speices of fish was collected during the course of the study. Yellow perch was one of the most abundant species collected. Difficulties were experienced in collecting sound

biological data due to a reduction of the length of the test system, and due to unfavorable weather and lake conditions. This resulted in the abandonment of numerous sampling stations and the establishment of new locations throughout the study. Only a few stations, therefore, survived the entire study period.

From usable data collected by the Fish and Wildlife Service during the Saginaw Bay thermal ice suppression test, the density of some food chain organisms (chironomids) was found to differ significantly between years. But within any given year the densities in areas receiving heated water did not differ markedly from those located in the unheated control areas.

An interesting observation was made with regard to the density of chironomids between the shipping channel and the bay floor areas. The density of organisms was found to be significantly more abundant on the shipping channel floor. One reason for this may be that the bottom substrate of the shipping channel has a higher organic content, which has been carried in by the polluted waters of the Saginaw River, than that of the bay floor substrate, which is more sandy.

Overall, statistical evidence did not show changes in species composition and abundance of fish in the study area. The study, however, was of short duration. Operational changes also were made in the test, and the study area probably was influenced by the polluted waters of Saginaw River, which may have overshadowed any subtle effect on fish that could be attributed to the release of heated water from the ice suppressor. In summary, the effects found, while measurable and statistically significant, cannot be labeled as either beneficial or adverse.

*Climatological investigations in the Lake Erie-Niagara River region*

A meteorological station was installed and monitored by the Buffalo District Corps of Engineers to determine the effects on local climatology of the ice boom installed each winter at the head of the Niagara River. In addition, two stations for the collection of solar radiation data were established at Port Maitland, Ontario, and Erie, Pennsylvania. Data collected from these stations included solar radiation measurements, temperature and humidity on a 24-hour basis, maximum and minimum temperature for daily calibration of a thermograph, average one-hour wind speeds and directions, and precipitation.

To gain insight into processes of ice formation and dissipation in the eastern end of Lake Erie an historical analysis was undertaken. Considered were: (1) the date of maximum summer water temperatures; (2) the date of 39° F water temperature in the fall; (3) the date of 32° F water temperature in the winter; (4) the date of 5-day average temperatures greater than 35° F; and (5) the date of 33° F water temperature in the spring for the pre-boom years 1935-36 and 1956-57 through 1963-64, and the post boom years 1964-65 through 1972-73.

Water temperature regimes which existed prior to boom installation, and those subsequent to installation, were compared by means of an inspectional analysis of the temperature record and detailed statistical analyses of the data. Water temperature data used were obtained from the Colonel Ward Filtration Plant at a depth of 18 feet at the Plant's water intake. Measurements were taken with a mercury-in-glass indicating thermometer since 1926 and a continuous recording device installed in 1959.

Analysis of data from the meteorological station near the Niagara River ice boom resulted in no effects detected on local climatology.

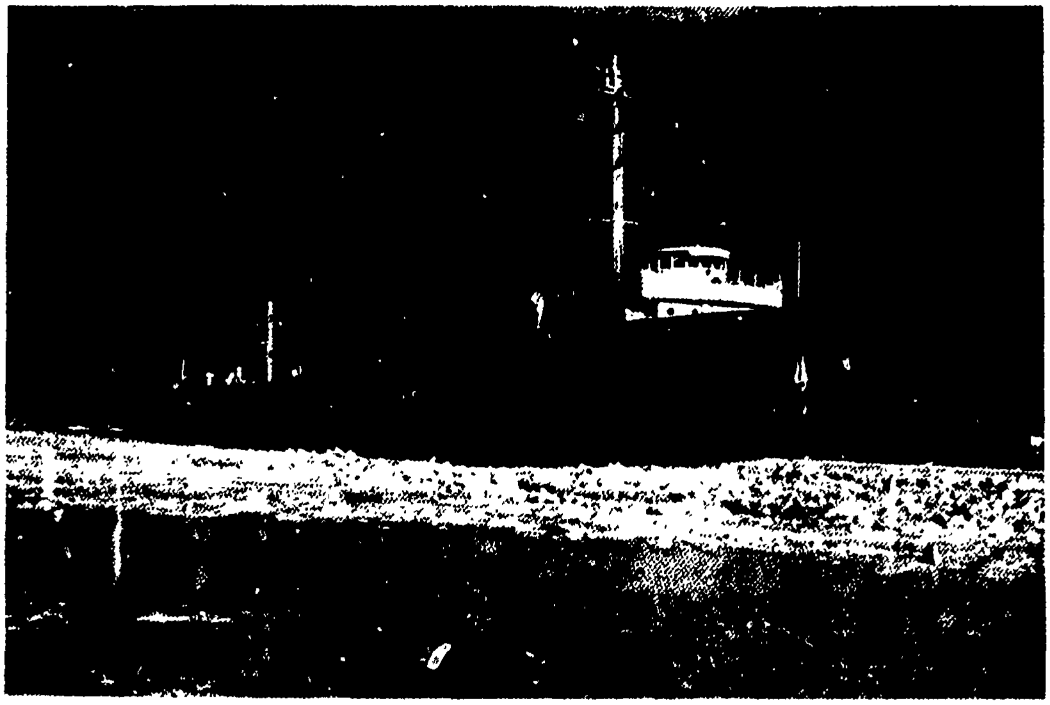
*Transport of oil and hazardous materials*

The Council of Environmental Quality (CEQ) Hazardous Materials Plan and the Coast Guard's Contingency Plan are effective and functioning programs for the recovery of hazardous substance spills.

The Coast Guard's Regional Contingency Plan is supportive of and supplements the CEQ Plan. Both materials and techniques used by the Coast Guard are the best currently available.

Should a spill occur during transport by water of many hazardous materials, the cost for clean-up is borne primarily by the owner of the facility which spilled the material. Financial responsibility is limited, however, and if clean-up costs exceed this limit, a "super fund" established by the Coast Guard, supplies remaining costs. Legislation is under review which will increase the financial liability of the owner to avoid excessive depletion of the Coast Guard fund.

Under the National Oil and Hazardous Substances Contingency Plan, the Coast Guard bears primary responsibility for coping with actual and potential spills. The Coast Guard has stated that the probability of a spill in winter is reduced for the following reasons. When vessel traffic continues through an extended season, tracks are established by preceding



*Oil tanker underway in heavy ice.*

ships and the risk of collision or grounding is less Vessels moving through ice are not able to move at high rates of speed; they are not able to move out of their tracks with ease; when they do start to get out of track, it is relatively easy to stop them because of the frictional effect of ice. There are a reduced number of vessels operating, and generally they are operating with an escort when they are in difficult waters; with lake waters completely or largely covered by ice, the effects of wind and waves are considerably reduced; and ice between ships tends to serve as a buffer to keep vessels away from danger.

If a spill should occur, ice and cold weather could affect containment operations, as well as oil recovery from stranded or sunken vessels Effects of ice and cold weather can be either beneficial or adverse depending on a given set of circumstances. These and other considerations are important to contingency planning. Unfortunately, there is little experience on which to focus, and each event is unique and requires its own approach, its own equipment, and its own solution.

A recently completed survey of cold regions oil spill mitigation technology included a cursory determination of the applicability of presently available means to the problems of detection, containment, recovery, temporary storage, and disposal of oil spilled in cold regions characterized by the existence of low temperatures and the presence of ice in many forms. The evaluations were based upon the experience of various persons conducting cold regions laboratory and field programs, and the experience of others in cold regions as reported in the technical literature. The survey revealed that a very limited degree of oil spill response capability is available for use in cold regions based upon the techniques and equipment currently employed in warmer climates. While this limited capability is available, a great deal of development work must be undertaken before a total cold regions oil spill response capability is available. Current technology falls short of the desired total response capability in all functional areas, including remote sensing, containment, recovery, temporary storage and disposal.

Should oil and hazardous material spills occur in an ice environment, special problems would include inadequacies in cleanup equipment, personnel, and

logistics inherent in the season and expanse of territorial occurrence. Yet, within four hours from initial notification, specially trained teams and the most sophisticated available containment, transfer, and cleanup equipment could be available at the nearest suitable airport in the Great Lakes. A river system, however, could pose additional problems due to the water regime and potential for rapid dispersion of the pollution.

The system and equipment currently in use by the Coast Guard represent a great improvement over past capability and are the best available for combatting oil and hazardous substance spills. The U.S. Fish and Wildlife Service has indicated the needs of fish and wildlife resource protection require improved capability in handling spills in fluvial waters and during winter conditions. The Coast Guard will continue research and development efforts in the field, including the requirement for double hulls on vessels carrying oil or hazardous material.

## Identification of social impact

### *Social Effects Work Group Report*

The examination of the social aspects of navigation season extension was compiled by the Great Lakes Basin Commission under the direction and guidance of the Social Effects Work Group of the Winter Navigation Working Committee.

The objective of their study was to identify and review significant social effects of winter navigation season extension activities, to recommend solutions on further investigations, and to prepare a plan of action to address unresolved concerns, including both perceived and real dimensions of social effects.

The study was carried out in three stages. The first consisted of a literature research to identify the known and documented social effects of winter navigation, and to record any actions taken to resolve these concerns. The second involved the identification of potential and previously unidentified social effects through public meetings and interviews, and the third was the preparation of a plan of action to address unresolved concerns and to suggest further investigations.

The Social Effects Work Group identified in its report, *The Social Aspects of Winter Navigation*, four major areas of social effect: (1) recreation; (2) shore erosion and structural damage; (3) cross channel transportation; and (4) occupational groups.

### *St. Marys River Recreation Study*

This study was conducted in conjunction with the Heritage Conservation and Recreation Service and Lake Superior State College to determine the effect of winter navigation on recreation -- primarily fishing and snowmobiling on the St. Marys River. The study was conducted at eleven major winter recreation sites along the navigation channel from Whitefish Point to DeTour Passage-Drummond Island and involved onsite observations and personal interviews of recreation participants.

The final result of the St. Marys River recreational study was that nearly one-third of the people interviewed indicated that extended navigation affected the quality of their recreational activity, primarily in ice fishing and snowmobiling. The majority of negative comments came from snowmobilers who were concerned with unsafe ice conditions.

### *Shore erosion and dock damage monitoring*

Complaints of shore and dock damage by owners of property along the navigation channels of the St. Marys River have come about as a result of the extension of the navigation season. An extensive study that involved identification of both erosion and dock damage was conducted. Specific docks were selected from each study area and visually inspected and photographed throughout the winter to detect movement or damage.

Similarly, a total of 12 profile sites were established in erosion-prone areas. Profiles were systematically remeasured over a 2½ year period to document any changes that may have occurred between stable shore and out into the 2-3 foot depth in the river. Ship-wave measurements were also taken during both ice and open water conditions to aid in the study.

That winter navigation does contribute to increased dock damage in certain areas of the St. Marys and St. Clair Rivers was indicated as a result of studies on these subjects. The studies indicated damage arising primarily from ice moving laterally and/or vertically against the structures.

### *Island transportation access efforts*

*Sugar Island activities:* One of the major problems associated with winter navigation in the St. Marys River is the disruption of traditional modes of transportation between the islands and the mainland

At the upstream end of Little Rapids Cut in the St.

Marys River, just below Soo Harbor, is located the Sugar Island ferry crossing. River currents at this point tend to keep the area relatively ice free through much of the winter. However, winds or thaw conditions will occasionally loosen ice in the harbor, which flows downstream to jam the Cut. Before the Winter Navigation Demonstration Program, this was an infrequent occurrence and would temporarily hamper ferry operation until the ice stabilized and the ferry track was reopened.

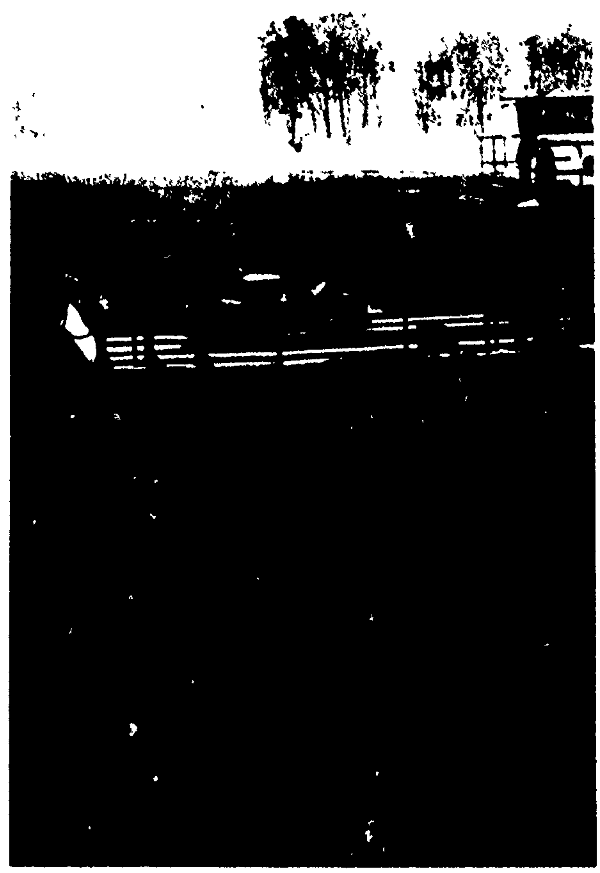
The ice cover in the Soo Harbor was disrupted by ship transit during the Winter Navigation Program, resulting in loose ice frequently filling the Cut and occasionally halting ferry operations until icebreakers could reopen the crossing area.

Modifications to the Sugar Island ferry were made to see if the ice operating capabilities of the ferry could be improved. Improvements included changing the shape of the bow at both ends and doubling the thickness of hull plates near the water line. The strength of the hull was also increased by adding plates to the side and installing longitudinal side girders. The vessel was repowered with two 300 horsepower engines, replacing the existing 100 horsepower engines. Also included were a new shaft, bearings, propellers, and a strengthened rudder. The new ice strengthened hull and more powerful engines were effective in allowing the ferry to operate through moving ice floes.

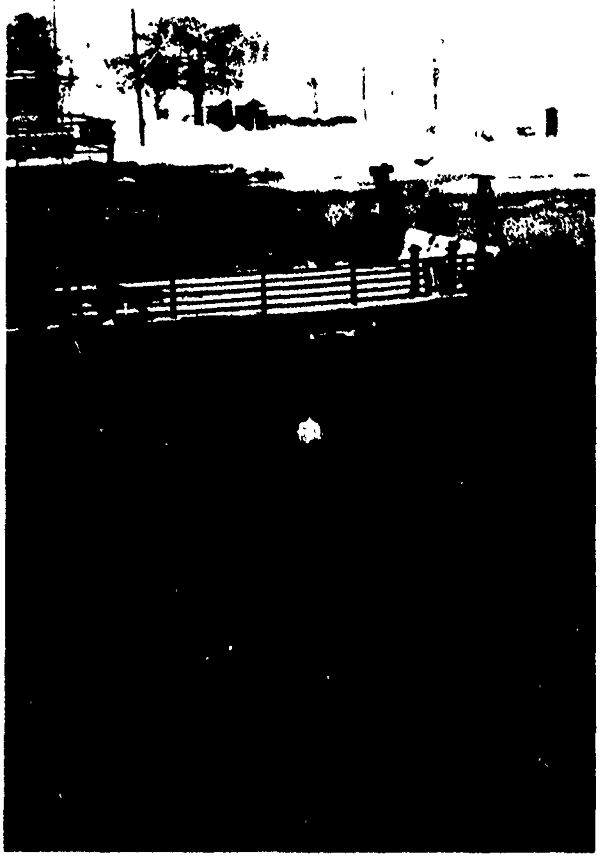
As mentioned previously, model studies and a prototype ice boom test were performed for the Little Rapids Cut to see if the ice cover could be stabilized and allow vessel transits. Since the annual installation of an ice boom in 1975, there has been no serious disruptions to ferry operation.

To assist the ferry in reaching the mainland dock, an air bubbler-flusher system was installed and operated each year. The system flushed ice away from the dock providing there was an area out in the channel into which the ice could be flushed.

To help maintain the transportation link at the Sugar Island ferry crossing, an operational plan was developed and implemented during the fourth through eighth years of the program. The U.S. Coast Guard Captain of the Port (Soo) was designated as Officer-in-Charge to coordinate and implement the operational plan efforts. The Coast Guard and a private tug performed preventative icebreaking in the area. In the event the ferry was temporarily unable to operate, Coast Guard vessels were used to provide transportation. If the National Weather Service's experimental forecasts indicated ferry service would be interrupted in excess of five consecutive days, shipping through the area would be halted until the area cleared enough to resume ferry operations.



Sugar Island Ferry moves across St. Marys River.



*Lime Island airboat:* Navigation season extension activities resulted in the disruption of the solid ice cover between Lime Island and the mainland. An airboat, capable of crossing solid or broken ice and open water was designed and constructed to provide transportation during the extended season.

A number of improvements were suggested by airboat users, including a new engine and propeller, a walk-through windshield, new passenger seats, canvas top and side curtains for the passenger compartment, and a sturdier engine mount.

The test airboat has not been accepted by the residents as an effective solution. They claim the vehicle is uncomfortable and inconvenient. The vehicle is old and if extended season navigation were to continue, a newer vehicle would be required.

*Closed West Neebish Channel:* During the open water season, upbound traffic uses the Middle Neebish Channel and downbound traffic transits the straighter West Neebish Channel. The Neebish Island ferry operates across the West Neebish Channel above a narrow excavated channel commonly called Rock Cut. When ice thickness is sufficient to support foot and snowmobile traffic, the West Neebish Channel is closed to navigation. The ferry service shuts down for the winter and both upbound and downbound navigation use the Middle Neebish Channel. Access to Neebish Island is across the ice until ferry service is resumed in the spring.

Various solutions are being investigated to provide access to the Island if the West Neebish Channel should be opened to winter navigation. However, the West Neebish Channel is not included in the proposed plan for winter navigation.

*Monitored Drummond Island crossing:* The Drummond Island ferry operates year-round across the mile-wide DeTour Passage, located where the St. Marys River flows into Lake Huron. Because ferry operators complained of unusually heavy ice floes and navigation problems shortly after the beginning of the Demonstration Program, a monitoring program was established to observe winter operations of the ferry.

A time-lapse movie camera was set up to record daily ferry operations throughout several winters. Aerial photos were taken to document the changing ice conditions, and a Corps observer made periodic crossings on the ferry, discussed operations with the ferry operators, and obtained copies of the daily crossing logs.

Results of the observations indicate that the extended navigation activities did not contribute to Drummond Island ferry problems. The problems arise

because the ferry has marginal ice operating capabilities and faces difficulty maneuvering in ice floes blown against shoreline docking facilities. The continuously maintained ship track, through the ice bridge upstream of the ferry crossing, severs the alternate means of transportation to the mainland (over the ice) when the primary means (the ferry) is out of service for repairs. This situation would continue to be monitored during any operational season to determine if there is any change in this situation.

*St. Clair River:* As part of the Detroit Districts Winter Operation Reporting Center operations a close watch was kept on all cross channel river traffic in the St. Clair and Detroit Rivers. It was determined that the impact of winter navigation on cross-channel transportation service is minimal.

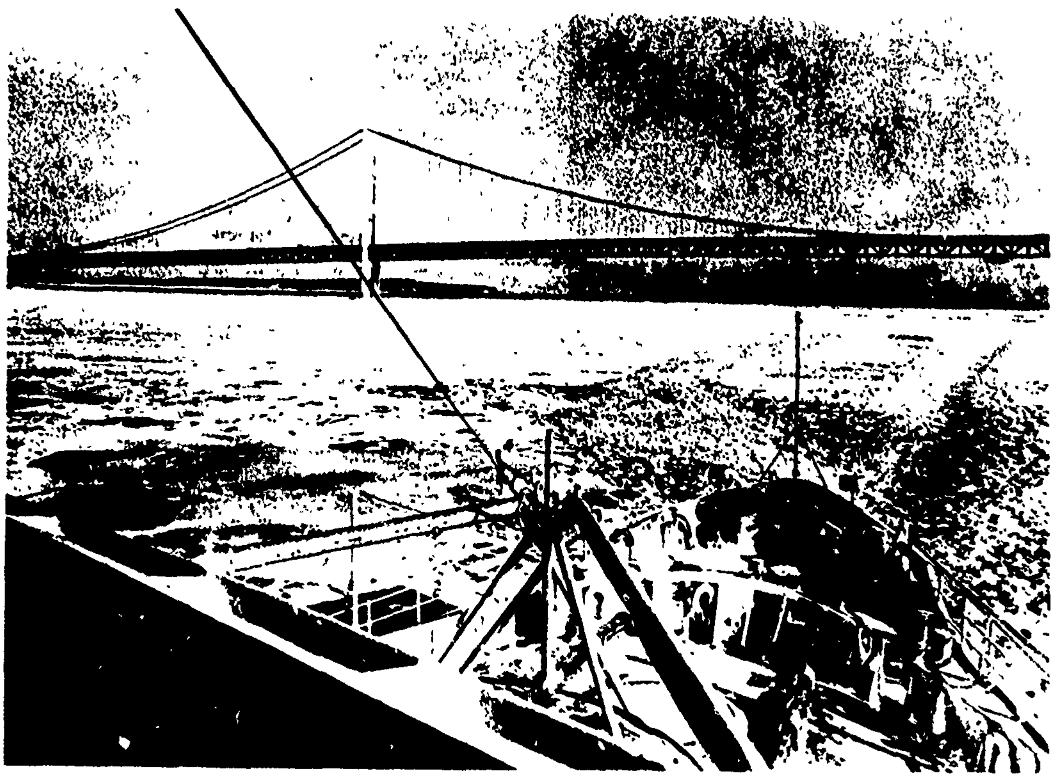
The Harsens Island ferry, operating between Algonac, Michigan and Harsens Island on the north channel of the St. Clair River has experienced interruptions in service for short periods of time (1 to 4 days) during the 1978-79 winter season. This is an area of naturally occurring ice jams of substantial proportion. This area would also be monitored during an operational season to determine if navigation increases these effects.

The Drummond Island and Harsens Island transportation issues remain unresolved and further studies are necessary.

*Sociological Assessment Study by MARAD*

The Maritime Administration (MARAD) con-

*Vessel transits Straits of Mackinac.*



*Upbound through Soo Locks.*

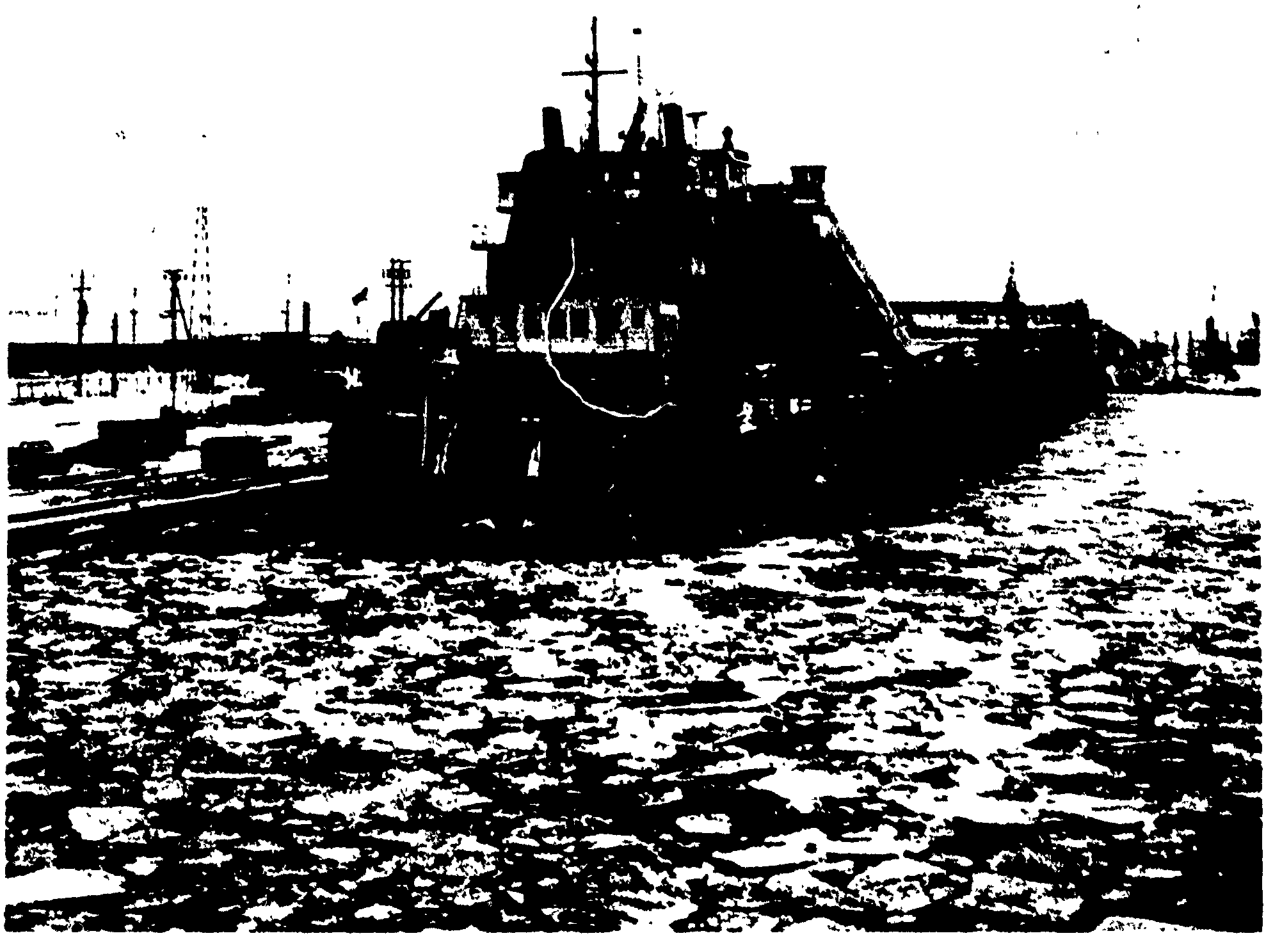
cluded a study in October 1976 aimed at identifying significant psychological probiems and benefits of an extended wintér navigation season on Great Lakes personnel. The study was entitled, "Sociological Assessment Survey" (SAS). A questionnaire was developed and directed to representative samples of Great Lakes industry groups, i.e., vessel, terminal, lock, and pilot personnel. Almost 1,700 questionnaires were distributed with a high response rate of approximately 46 percent.

Four occupational groups have been identified as being directly affected by winter navigation activities -- personnel employed by vessels, terminals, locks and as pilots. The effects on these groups are primarily two: individual comfort and the psycho-socio effects of an extended season. The results of the Maritime Administration Sociological Assessment Survey are summarized below:

*Vessel personnel:* Although these individuals have positive attitudes toward their jobs, they appear somewhat negative with regard to the extended season. They are concerned about safety during the winter, feeling the need for more time off, indicating that sailing during the extended season is disturbing to their families. The group did exhibit a positive attitude in situations where individuals either sailed voluntarily or knew several months in advance that they would be sailing during the extended season. Serious psycho-socio problems related to extension are anticipated with this group, although several suggestions were made to improve season extension acceptance.

*Lock and terminal personnel:* While virtually all lock and many terminal personnel were positive toward an extended season, union terminal personnel exhibited more negative attitudes than non-union terminal workers. The group provided suggestions aimed at improving conditions relating to winter navigation. As with other groups, they asked for more information

Presque Isle *works under winter conditions.*



concernir ., the extension. Different segments of this group seemed to prefer particular job assignments, although not necessarily the most easy or comfortable ones. These preferences should be honored or retraining should be initiated to accommodate them.

Finally, some personnel (union members) expressed less job satisfaction and less positive attitudes toward extension than non-union members. It would be helpful to solicit suggestions from these union members regarding their season extension concerns.

*Pilot personnel:* Some tentative suggestions may be made regarding this group, although few responses were received. Initially, this group needs more extensive information on season extension. Suggestions from the group should be actively solicited. The possibility of having more pilots available during the extended season should be explored.

Pilots should be better informed about upcoming changes in their work schedules and be allowed to provide input or discussion about these changes. The use of volunteers is also suggested. Vacation schedules should be altered to allow pilots to take vacations during summer months.

*Winter Cargo Handling Study*

The Great Lakes Regional Office of MARAD conducted a study, entitled "The Effects of Winter Weather on Cargo Handling Productivity," as an in-house project. The objective of the study was to determine the effects of adverse winter weather on cargo handling productivity at Great Lakes Ports and terminals, to analyze these effects, and to make recommendations on methods or techniques (if any) which would improve productivity to the degree that the competitive posture of Great Lakes Ports would be improved.

The results of the study on the effect of winter weather on cargo handling productivity is based on a survey of terminal operators, shipping lines and labor organizations in the Great Lakes area. The consensus of the survey indicated that the effects of winter weather did not have a severe impact on cargo handling operations, with the exception of bulk coal loading and unloading. This commodity has been identified for further study due to the intermodal aspects and the nature of the cargo itself.

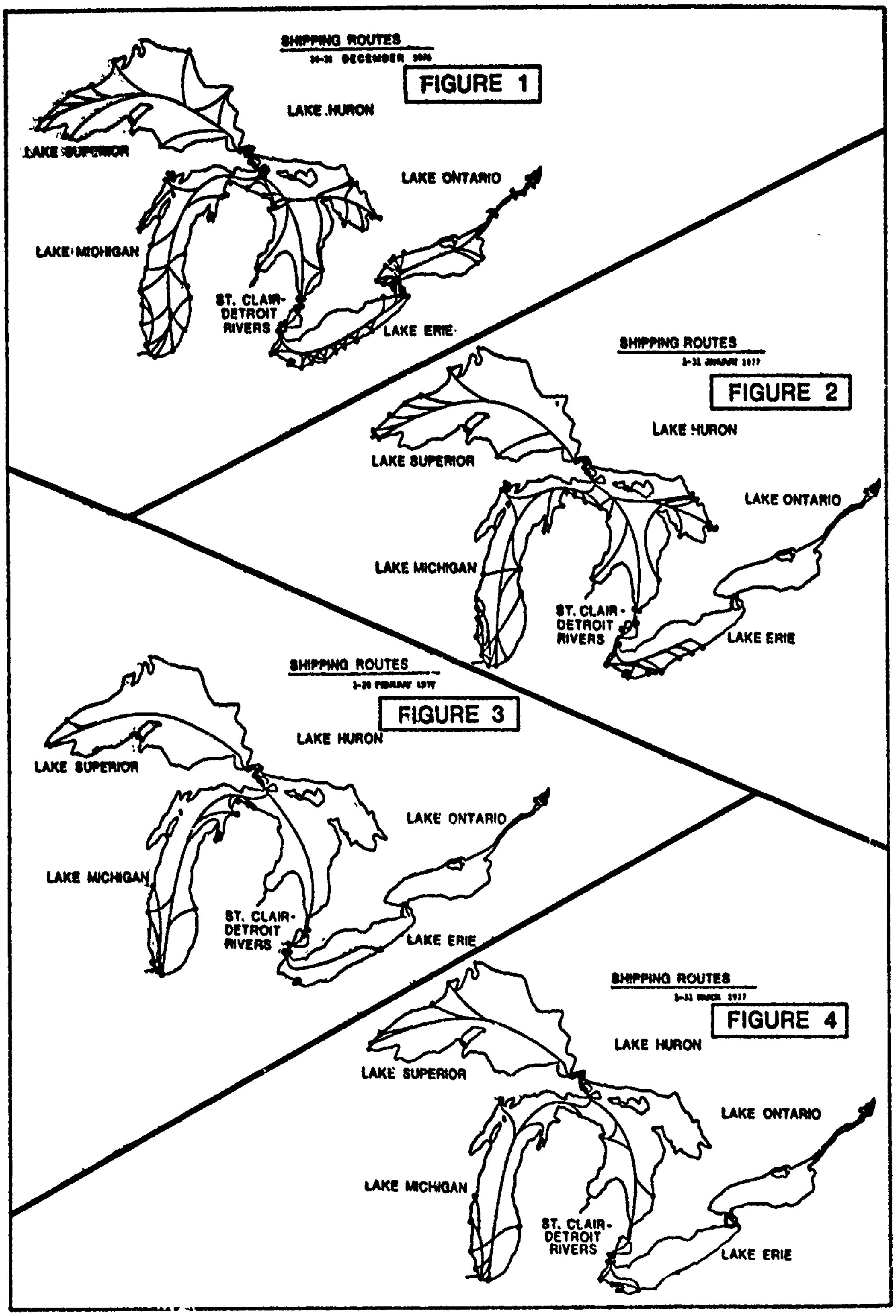
Other specific findings of the study indicated that winter weather was not significantly detrimental to productivity as long as safety considerations were applied and adequate winter clothing was made available at a moderate cost to employees. Standardized or issued cold-weather clothing was not seen to be an alternative either by labor or management, due to the variance in individual taste and desires.

Work stoppages during winter were seen as being no more frequent than those caused by summer rain storms. Benefits to labor and to ports in terms of year-round employment would occur as a result of the extension effort, with no degradation of experienced personnel.

Benefits from increased revenues would offset equipment maintenance costs; very little special equipment (except for snow removal equipment) would be needed. Most ports currently consider themselves to be operational on a year-round basis already, due to transshipment requirements.

This study applies particularly well to winter navigation, since it resolves the issue of the capability of Great Lakes ports and terminals to operate during the winter season, should such operations become a reality.

*Shipping routes, winter of 1976-77.*



## Economics

*Traffic study*

The primary activity undertaken by the Economic Evaluation Work Group during the Demonstration Program was a Traffic Study of all commodities shipped on the Great Lakes during each year of the Program. An origin-destination traffic matrix was prepared for each year of extended season traffic based on data obtained from Soo Locks records, from vessel operation reports of U.S. companies that ship on the Great Lakes, and from a telephone/mail survey of Canadian companies that ship on the Lakes.

The results of the Traffic Study are depicted in Table I for FY 72-78 (FY 79 data have not yet been completed). As shown in Part A of Table I, the total net tonnage handled on the Great Lakes during the extended navigation season increased steadily from 3.6 million tons in FY 72 to 15.0 million tons in FY 75, then decreased annually to 5.3 million in FY 77, before increasing again in FY 78 to 9.1 million tons.

Iron ore accounted for a record 74 percent of all commodities shipped during the FY 78 extended season (due primarily to the iron ore mine workers' strike in 1977 forcing companies to ship more ore during the 1977-78 winter) and maintained its position as the primary commodity shipped from FY 72 through FY 78 (Table I, Part B). Net tonnage by Lake of origin is shown in Part C of Table I. During each of the extended seasons, Lake Superior has been the major Lake of origin. Part D of Table I illustrates the fact that Lake Michigan was the major lake of destination in the FY 78 extended season, as it has been in every year except FY 73.

Overall, Parts A, B, C, and D show that the primary extended season commodity movement during the Demonstration Program has been iron ore originating out of Lake Superior and destined for Lake Michigan, Lake Erie, and the St. Clair-Detroit Rivers System.

Figures 1 through 4 show the typical Great Lakes shipping routes for each month of extended season operation, based on the Demonstration Program tonnages contained in Table I. As can be evidenced from these figures, traffic movements are heaviest in December, then gradually decline in January and February, and increase again in March as the winter season comes to a close.

Table II shows the opening and closing dates, transits and tonnage for the Soo Locks for the 1967-1978 extended navigation seasons. As this table shows, the Soo Locks have remained open all year for the past five winters (although, from 23 January 1977 to 17 March 1977 the Demonstration Program was suspended). A record 9,134,539 tons of commerce passed through the locks during the 1974 extended season, while 1977 was the second highest year with 6,844,222 tons and 1978 the third highest year with 6,629,598.

A summary of the market value of the annual waterborne commerce passing through the Soo Locks during the 1971-1978 extended navigation seasons is shown in Table III. This table also points out the fact that the average annual amount of tonnage moving through the Soo Locks during the 1971-1978 extended navigation season period was 5,165,900 tons with an average annual market value of $300,231,100. (This figure indicates market value and not savings gained by an extended navigation season). It should be noted that the market values of the various tonnages displayed in Table III do not include the transport costs that would be associated with moving these goods from the point of origin to the point of destination. As an example, the total transport cost to rail iron ore (the primary commodity shipped during the Demonstration Program) from the Mesabi range to Duluth-Superior and then transship it by vessel to a Lake Erie port would be approximately $9.54 per ton. This $9.54 per ton includes all dock and handling charges, and represents nearly one-fourth of the $37.50 per ton market value of iron ore shown in Table III.

## TABLE I
## COMPARISON OF FY 72 THROUGH FY 78
## GREAT LAKES EXTENDED NAVIGATION SEASONS

### Part A
### TOTAL NET TONNAGE[1]

NET TONS

| Commodity | FY 72 | FY 73 | FY 74 | FY 75 | FY 76 | FY 77 | FY 78 |
|---|---|---|---|---|---|---|---|
| Iron Ore | 1,175,967 | 3,900,872 | 4,927,019 | 8,399,424 | 5,493.064 | 2,569.129 | 6,733,582 |
| Grain | 709,679 | 623,752 | 1,099,289 | 1,712,258 | 1,289.297 | 775.177 | 947,557 |
| Coal | 1,127,263 | 663,891 | 1,654,906 | 2,229,582 | 1,685.214 | 870.525 | 513,204 |
| Stone | 140,516 | 493,886 | 1,117,092 | 1,140.778 | 509,019 | 231.649 | 319,137 |
| Petroleum | 368,341 | 757,728 | 985,052 | 1,015,124 | 590.542 | 607.675 | 407,849 |
| Others | 55,589 | 294,095 | 845,241 | 516,396 | 96.488 | 237.042 | 164.661 |
| TOTALS | 3,577,355 | 6,734,224 | 10,628,599 | 15,013.562 | 9.663.624 | 5.291.197 | 9.085,990 |

1. Reflects total net tonnage moved on the Great Lakes-St. Lawrence Seaway system as opposed to tonnage moved through the Soo Locks.

INDEX OF CHANGE: FY 72=100

| Commodity | FY 72 | FY 73 | FY 74 | FY 75 | FY 76 | FY 77 | FY 78 |
|---|---|---|---|---|---|---|---|
| Iron Ore | 100 | 332 | 419 | 714 | 467 | 218 | 573 |
| Grain | 100 | 88 | 155 | 241 | 182 | 109 | 134 |
| Coal | 100 | 59 | 147 | 198 | 150 | 77 | 46 |
| Stone | 100 | 351 | 795 | 812 | 362 | 165 | 227 |
| Petroleum | 100 | 206 | 267 | 275 | 160 | 165 | 111 |
| Others | 100 | 529 | 1,520 | 929 | 174 | 426 | 296 |
| TOTALS | 100 | 188 | 298 | 420 | 270 | 148 | 254 |

**TABLE I (continued)**
**Part B**
**TOTAL NET TONNAGE BY COMMODITY**

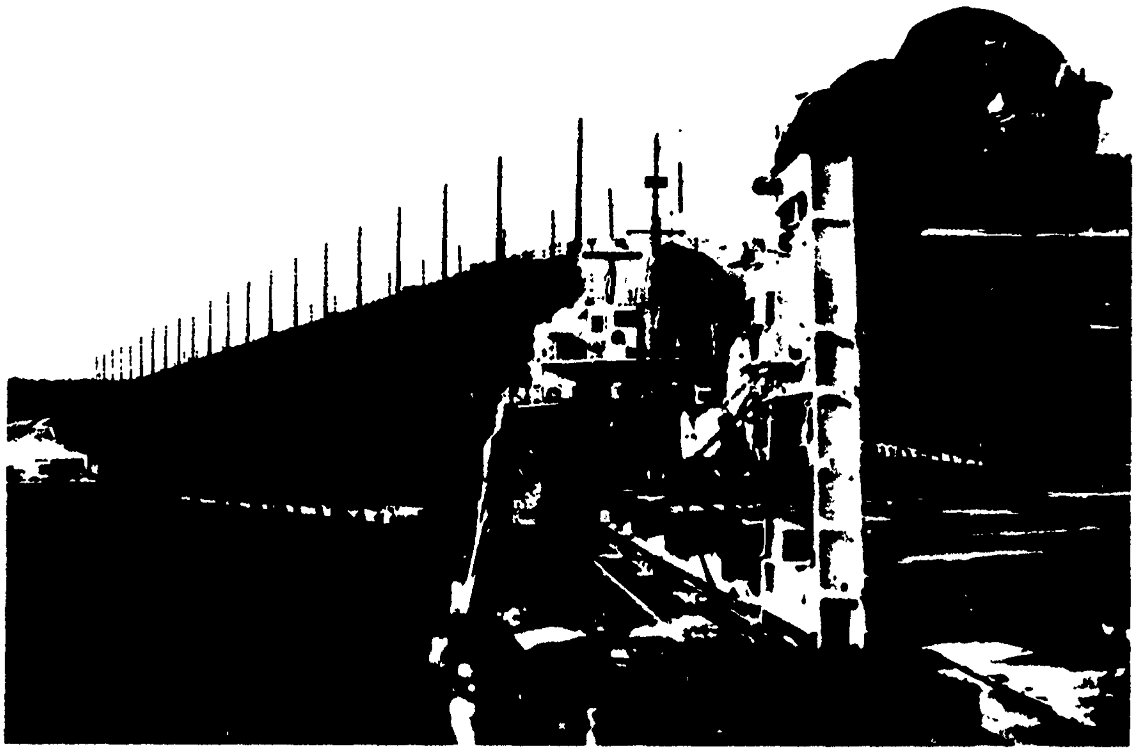
**% of Total Net Tonnage**

| Commodity | FY 72 (3,557,355) | FY 73 (6,734,224) | FY 74 (10,628,599) | FY 75 (15,013,562) | FY 76 (9,663,624) | FY 77 (5,291,197) | FY 78 (9,085,990) |
|---|---|---|---|---|---|---|---|
| Iron Ore | 33% | 58% | 46% | 56% | 57% | 49% | 74% |
| Grain | 20 | 9 | 10 | 11 | 13 | 15 | 10 |
| Coal | 31 | 10 | 16 | 15 | 18 | 16 | 6 |
| Stone | 4 | 7 | 11 | 8 | 5 | 4 | 4 |
| Petroleum | 10 | 12 | 9 | 7 | 6 | 11 | 4 |
| Others | 2 | 4 | 8 | 3 | 1 | 5 | 2 |
| TOTALS | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

**Part C**
**TOTAL NET TONNAGE BY LAKE OF ORIGIN**

**% of Total Net Tonnage**

| LAKE OF ORIGIN | FY 72 (3,577,355) | FY 73 (6,734,224) | FY 74 (10,628,599) | FY 75 (15,013,562) | FY 76 (9,663,624) | FY 77 (5,153,561) | FY 78 (9,085,990) |
|---|---|---|---|---|---|---|---|
| Lake Superior | 54% | 56% | 48% | 61% | 59% | 55% | 75% |
| Lake Michigan | 9 | 24 | 21 | 11 | 16 | 13 | 10 |
| Lake Huron | 3 | 5 | 9 | 7 | 4 | 4 | 5 |
| St. Clair-Detroit Rivers | 1 | 2 | 5 | 3 | 2 | 8 | 3 |
| Lake Erie | 32 | 12 | 16 | 16 | 18 | 19 | 6 |
| Lake Ontario | 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| TOTALS | 100% | 100% | 100% | 100% | 100% | 100% | 100% |



*Winter activity.*

**TABLE I (continued)**
**Part D**
**TOTAL NET TONNAGE BY LAKE OF DESTINATION**

**% of Total Net Tonnage**

| LAKE OF DESTINATION | FY 72 (3,463,470) | FY 73 (6,700,408) | FY 74 (10,594,578) | FY 75 (14,113,239) | FY 76 (9,568,327) | FY 77 (5,291,197) | FY 78 (9,030,249) |
|---|---|---|---|---|---|---|---|
| Lake Superior | 3% | 3% | 3% | 7% | 5% | 8% | 8% |
| Lake Michigan | 36 | 36 | 35 | 31 | 39 | 40 | 47 |
| Lake Huron | 5 | 3 | 6 | 6 | 6 | 5 | 6 |
| St. Clair-Detroit Rivers | 23 | 17 | 24 | 18 | 11 | 19 | 4 |
| Lake Erie | 11 | 37 | 23 | 25 | 28 | 11 | 25 |
| Lake Ontario | 22 | 4 | 9 | 13 | 11 | 17 | 10 |
| TOTALS | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

*Moving toward the Soo Locks.*

**TABLE II**
**SOO LOCKS TRANSITS AND TONNAGE**
**AFTER NORMAL SEASON CLOSING DATE (DECEMBER 16)**

| Season | Opening Date | Closing Date | Transits[1] UP | DN | TL | Tonnage |
|---|---|---|---|---|---|---|
| 1967 | 1 April 67 | 31 Dec 67 | 15 | 25 | 40 | 398,978 |
| 1968 | 1 April 68 | 4 Jan 69 | 22 | 32 | 54 | 471,542 |
| 1969 | 1 April 69 | 11 Jan 70 | 37 | 56 | 93 | 1,020,050 |
| 1970 | 1 April 70 | 29 Jan 70 | 66 | 86 | 152 | 1,423,612 |
| 1971 | 1 April 71 | 1 Feb 72 | 86 | 107 | 193 | 1,976,407 |
| 1972 | 1 April 72 | 8 Feb 73 | 144 | 179 | 323 | 3,362,974 |
| 1973 | 1 April 73 | 7 Feb 74 | 192 | 226 | 418 | 4,780,003 |
| 1974 | All Year | | 368 | 395 | 763 | 9,134,539 |
| 1975 | All Year | | 210 | 233 | 443 | 5,664,689 |
| 1976 | All Year | | 119 | 131 | 250 | 2,935,011 |
| 1977 | All Year | | 279 | 297 | 576 | 6,844,222 |
| 1978 | All Year | | 252 | 284 | 536 | 6,629,598 |

[1]UP indicates upbound, DN indicated downbound, and TL indicates total transits

TABLE III

MARKET VALUE OF WATERBORNE COMMERCE
PASSING THROUGH THE SOO LOCKS DURING NAVIGATION
EXTENDED SEASONS 1971-1976

| Ext. Sea Yrs. | IRON ORE | COAL | STONE | GRAIN | PETROLEUM PRODUCTS | OTHER BULK 2/ | GENERAL CARGO 3/ | TOTAL |
|---|---|---|---|---|---|---|---|---|
| **1971** | | | | | | | | |
| NET TONS 1/ | 1,136,971 | 62,566 | - | 709,679 | 16,741 | 16,858 | 33,592 | 1,976,407 |
| AVG VALUE PER TON | $ 37.50 | 29.95 | - | 129.58 | 129.86 | 10.00 | 484.00 | |
| TOTAL MARKET VALUE | $ 42,636,400 | 1,873,900 | - | 91,960,200 | 2,174,000 | 168,600 | 16,258,500 | $155,071,600 |
| **1972** | | | | | | | | |
| NET TONS 1/ | 2,673,947 | 61,959 | - | 553,424 | 8,885 | 12,366 | 52,393 | 3,362,974 |
| AVG VALUE PER TON | $ 37.50 | 29.95 | - | 129.58 | 129.86 | 10.00 | 484.00 | |
| TOTAL MARKET VALUE | $100,273,200 | 1,855,700 | - | 71,712,700 | 1,153,800 | 123,700 | 25,358,200 | $200,477,100 |
| **1973** | | | | | | | | |
| NET TONS 1/ | 3,674,433 | 103,331 | 20,508 | 925,377 | 9,337 | 16,767 | 30,250 | 4,780,003 |
| AVG VALUE PER TON | $ 37.50 | 29.95 | 2.08 | 129.58 | 129.86 | 10.00 | 484.00 | |
| TOTAL MARKET VALUE | $137,791,200 | 3,094,800 | 42,700 | 119,910,400 | 1,212,500 | 167,700 | 14,641,000 | $276,860,300 |
| **1974** | | | | | | | | |
| NET TONS 1/ | 6,889,452 | 563,116 | 62,317 | 1,487,298 | 18,671 | 43,709 | 69,976 | 9,134,539 |
| AVG VALUE PER TON | $ 37.50 | 29.95 | 2.08 | 129.58 | 129.86 | 10.00 | 484.00 | |
| TOTAL MARKET VALUE | $258,354,500 | 16,865,300 | 129,600 | 192,724,100 | 2,424,600 | 437,100 | 33,868,400 | $504,803,600 |
| **1975** | | | | | | | | |
| NET TONS 1/ | 4,163,036 | 322,313 | - | 1,113,919 | 15,170 | 18,700 | 31,551 | 5,664,689 |
| AVG VALUE PER TON | $ 37.50 | 29.95 | - | 129.58 | 129.86 | 10.00 | 484.00 | |
| TOTAL MARKET VALUE | $156,113,900 | 9,6 3,300 | - | 144,341,600 | 1,970,000 | 187,000 | 15,270,700 | $327,536,500 |
| **1976** | | | | | | | | |
| NET TONS 1/ | 1,991,407 | 105,567 | 34,502 | 669,143 | 58,820 | 21,700 | 53,872 | 2,935,011 |
| AVG VALUE PER TON | $ 37.50 | 29.95 | 2.08 | 129.58 | 129.86 | 10.00 | 484.00 | |
| TOTAL MARKET VALUE | $ 74,677,800 | 3,161,700 | 71,800 | 86,707,500 | 7,638,400 | 217,000 | 26,074,000 | $198,548,200 |

| Ext Sea. Yrs 1977 | IRON ORE | COAL | STONE | GRAIN | PETROLEUM PRODUCTS | OTHER BULK 2/ | GENERAL CARGO 3/ | TOTAL |
|---|---|---|---|---|---|---|---|---|
| NET TONS 1/ | 5,643,722 | 77,877 | 39,987 | 859,109 | 455,454 | 16,807 | 51,265 | 6,844,222 |
| AVG. VALUE PER TON | $ 37.50 | 29.95 | 2.08 | 129.58 | 129.86 | 10.00 | 484.00 | |
| TOTAL MARKET VALUE | $211,639,600 | 2,332,400 | 83,200 | 111,323,300 | 20,187,300 | 168,100 | 24,812,700 | $370,546,600 |
| **1978** | | | | | | | | |
| NET TONS 1/ | 5,193,613 | 124,637 | 170,518 | 898,103 | 182,049 | - | 60,678 | 6,629,598 |
| AVG. VALUE PER TON | $ 37.50 | 29.95 | 2.08 | 129.58 | 129.86 | - | 484.00 | |
| TOTAL MARKET VALUE | $194,760,500 | 3,732,900 | 354,700 | 116,376,200 | 23,640,900 | - | 29,368,200 | $368,233,400 |

## AVERAGE TONNAGE AND AVERAGE MARKET VALUE OF EXTENDED SEASONS 1971-1978

| 1971-1978 | IRON ORE | COAL | STONE | GRAIN | PETROLEUM PRODUCTS | OTHER BULK | GENERAL CARGO | TOTAL |
|---|---|---|---|---|---|---|---|---|
| NET AVERAGE TONS 1/ | 3,920,800 | 177,700 | 41,000 | 902,000 | 58,100 | 18,400 | 47,900 | 5,165,900 |
| AVG. VALUE PER TON | $ 37.50 | 29.95 | 2.08 | 129.58 | 129.86 | 10.00 | 484.00 | |
| TOTAL AVERAGE MARKET VALUE | $147,030,000 | 5,322,100 | 85,300 | 116,881,200 | 7,544,900 | 184,000 | 23,18 .600 | $300,231,100 |

1 Source of market value per ton of cargo: Iron ore Skillings Mining Review, 25 August 1979; Coal Federal Energy Regulatory Commission 1979, Average contract price per ton for east and north central states; Stone Presque Isle Corporation Long Lake, Michigan, 14 September 1979, Grain Wall Street Journal (cash prices), 23 January 1979; Petroleum products Wall Street Journal (cash prices), 23 January 1979; Other Bulk estimated based on product mix; General Cargo U.S. Department of Commerce, Bureau of Census, **Domestic and International Transportation of U.S. Foreign Trade**, 1976

2 Includes Paper and Woodpulp; Lumber, and Logs; and Non-Metallic Minerals

3 Includes Miscellaneous Merchandise, Manufactured Iron & Steel, Pig Iron and Scrap Iron

TABLE IV

**DISTRIBUTION OF DEMONSTRATION PROGRAM FUNDS**
**COST (1) BY FISCAL YEAR**

| ICE INFORMATION | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979(2) | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| **NOAA-Great Lakes Environmental Research Laboratory** | | | | | | | | | |
| (a) Air and water temperature measurements | $ 5.2 | $ 6.9 | $ 10.0 | $ 6.5 | $ - | $ - | $ - | $ - | $ 28.6 |
| (b) Lake Superior bathythermograph measurements | - | 11.0 | 6.0 | 6.5 | - | - | - | - | 23.5 |
| (c) Ice thickness measurements | 7.1 | 13.6 | 4.5 | 4.5 | - | - | - | - | 29.7 |
| (d) Aerial photography of selected areas | 17.7 | 24.0 | 4.0 | - | - | - | - | - | 45.7 |
| (e) St. Lawrence River freeze-up forecasts | - | 30.0 | 30.0 | - | - | - | 40.0 | 40.0 | 140.0 |
| (f) Harbor freeze-up forecasts | - | - | 20.0 | - | - | - | - | - | 20.0 |
| (g) Little Rapids Cut ice condition forecasts | - | - | 20.0 | - | - | - | - | - | 20.0 |
| **U.S. Coast Guard** | | | | | | | | | |
| (a) Operation of Navigation Center | 30.5 | 14.1 | 21.0 | 21.0 | 23.0 | 19.0 | 38.0 | 85.0 | 251.6 |
| (b) Coast Guard Ice Reconnaissance | 11.5 | 22.7 | 26.0 | 10.8 | 11.0 | - | - | - | 82.0 |
| **NOAA - National Weather Service** | | | | | | | | | |
| (a) Ice and weather forecast operations | 33.0 | 57.0 | 57.0 | 57.0 | 70.0 | 36.0 | 72.0 | 82.0 | 464.0 |
| (b) Short-Term ice forecast technique | - | 13.0 | 15.0 | - | - | - | - | - | 28.0 |
| (c) Harbor freeze-up and break-up forecasts | - | - | 20.0 | - | - | - | - | - | 20.0 |
| **St. Lawrence Seaway Development Corporation** | | | | | | | | | |
| St. Lawrence River Surveillance and monitoring | 50.0 | 40.0 | 55.0 | 125.0 | 120.0 | - | - | - | 390.0 |
| Document St. Lawrence River Ice conditions | - | - | - | - | - | - | 150.0 | - | 150.0 |
| **Corps of Engineers - Detroit District** | | | | | | | | | |
| (a) Ice thickness and movement measurement and water level fluctuations in St Clair and St Marys River | 65.0 | 53.7 | 50.8 | 23.8 | 7.2 | 9 | 14.9 | - | 216.3 |

## TABLE IV (continued)

| ICE INFORMATION (continued) | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979(2) | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| (b) Temperature profiles in selected areas | - | 5.0 | 2.8 | 3.4 | - | - | - | - | 11.2 |
| (c) Instrumentation of Pile movement and heaving - Great Lakes Area | - | - - | - | 21.0 | - | - | - | - | 21.0 |
| (d) Whitefish Bay Pressure Wave Study | - | - | - | - | - | - | 7.8 | - | 7.8 |
| **Corps of Engineers - Buffalo District** | | | | | | | | | |
| Eastern Lake Erie ice surveillance activities | 13.0 | 7.0 | 12.0 | 4.8 | - | - | - | - | 36.8 |
| **U.S. Army Electronic Proving Grounds** | | | | | | | | | |
| Remote sensing of Lake ice conditions (SLAR) | - | - | 80.0 | - | | - | - | - | 80.0 |
| TOTAL - ICE INFORMATION | 233.0 | 298.0 | 434.1 | 284.3 | 231.2 | 55.9 | 322.7 | 207.0 | 2066.2 |

(1) Rounded in thousands of dollars.
(2) Estimated costs pending financial closeout

| ICE MANAGEMENT | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979(2) | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| **Corps of Engineers - Detroit District** | | | | | | | | | |
| (a) Island Transportation Investigations | $13.5 | $ - | $ - | $ - | $ - | $ - | $ 8.4 | $ - | $ 21.9 |
| (b) Sugar Island ferry dock bubbler-flusher systems | 9.9 | 7.9 | 1.5 | 2.7 | 5.9 | 12.0 | 3.8 | 10.0 | 53.7 |
| (c) Modification of Sugar Island ferry | - | 73.0 | - | 10.0 | - | - | - | - | 83.0 |
| (d) Lime Island Airboat | - | 6.0 | 9.4 | 6.7 | 3.6 | 11.7 | 12.6 | 8.0 | 58.0 |
| (e) Lime Island Air-Bubbler System | 64.6 | 59.8 | - | - | - | - | - | - | 124.0 |
| (f) Design of Bubbler System for Middle Neebish Channel | - | 2.0 | - | - | - | - | - | - | 2.0 |
| (g) St Clair - Detroit River System Study | - | 80.2 | - | - | - | - | - | - | 80.2 |

TABLE IV (continued)

| ICE MANAGEMENT (continued) | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979(2) | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| (h) Saginaw Bay thermal Ice Suppression Test design, construction, testing, and removal | - | 8.9 | 10.0 | 299.5 | 67 6 | - | - | 3 0 | 389.0 |
| (i) Model study of Little Rapids Cut | - | - | 24.8 | 202.3 | 61.7 | - | - | - | 288.8 |
| (j) St. Marys River navigation ice boom design, construction, testing | - | - | - | 40.0 | 628.8 | - | - | - | 668.8 |
| (k) St. Marys River ice boom, modification, repairs, reinstallation and removal and redesign | - | - | - | - | - | 65.4 | 100 9 | 50.0 | 216.3 |
| (l) Advance Work - St. Marys River ice boom | - | - | - | - | 47.8 | - | - | - | 47.8 |
| (m) Analysis and data collection Saginaw Bay thermal ice suppression | - | - | - | - | 12.0 | - | - | - | 12.0 |
| (n) Instrumentation of ice boom St. Marys River | - | - | - | - | 67.0 | - | - | - | 67 0 |
| (o) Shore erosion and structure damage | - | - | - | - | 45 0 | - | - | - | 45.0 |
| (p) Analytical study St. Clair River physical hydraulic/ice model | - | - | - | - | - | - | 10 0 | - | 10.0 |
| (q) St. Clair River physical hydraulic/ice model | - | - | - | - | - | - | 311.6 | 183.4 | 495.0 |
| (r) St. Clair River model field data support | - | - | - | - | - | - | 22.8 | 22.0 | 44.8 |
| (s) St. Lawrence River levels and flows | - | - | - | - | - | - | 8.6 | 25 0 | 33.6 |
| (t) Madeline Island airboat tests | - | - | - | - | - | - | 1.8 | - | 1.8 |
| (u) Winter Navigation Reporting Center operation | - | - | - | - | - | - | 10 0 | 10.0 | 20.0 |
| (v) Shore erosion/dock damage | - | - | - | - | - | - | 15.4 | 50.0 | 65.4 |
| (w) Galop Island flow distrubution | - | - | - | - | - | - | - | 2.2 | 2.2 |
| **Corps of Engineers - St. Paul District** | | | | | | | | | |
| (a) Preparation of a report on FY-71 Duluth Harbor bubbler system | 5.0 | - | - | - | - | - | - | - | 5.0 |
| (b) Superior Harbor entrance bubbler system | - | 5.0 | - | - | - | - | - | - | 5.0 |
| (c) Howards Bay, Superior Harbor bubbler system | - | 55.0 | 60.0 | - | - | - | - | - | 115.0 |
| **Corps of Engineers - Buffalo District** | | | | | | | | | |
| Niagara River ice boom study | - | 12.0 | - | - | - | - | - | - | 12.0 |
| **U.S. Fish and Wildlife Service** | | | | | | | | | |
| Environmental data collection, Saginaw Bay thermal ice suppression test | - | 25.0 | 40 0 | 18.0 | 65 0 | - | - | - | 148 0 |
| Documentation mathmetical model | - | - | - | - | - | - | - | 3 0 | 3.0 |
| TOTAL - ICE MANAGEMENT | 93 0 | 334.8 | 145.7 | 579.2 | 1004 4 | 89 1 | 505 9 | 366 6 | 3118.7 |

## TABLE IV (continued)

| ICE NAVIGATION | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979(²) | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| **U.S. Coast Guard** | | | | | | | | | |
| (a) Water bubbler test on USCG RARITAN | $ 60.2 | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ 60.2 |
| (b) Follow-The-Wire navaid test, Muskegon Harbor | 2.2 | - | - | - | - | - | - | - | 2.2 |
| (c) Icebreaker support in Straits area | 38.0 | - | - | - | - | - | - | - | 38.0 |
| (d) Fixed and floating aids to navigation tests | 17.0 | 110.0 | 75.0 | 25.0 | - | - | - | - | 227.0 |
| (e) Laser range and radio transponder beacon (RACON) aids to navigation test | 2.6 | 33.2 | 15.0 | - | - | - | - | - | 50.8 |
| (f) Crew safety and survival tests | - | 125.0 | 240.0 | 35.0 | 25.0 | - | - | - | 425.0 |
| (g) Bubbler-wire guidance system studies and design for Whitefish Bay | - | 22.1 | - | - | - | - | - | - | 22.1 |
| (h) Water cannon non-conventional icebreaking tests | - | 23.7 | - | - | - | - | - | - | 23.7 |
| (i) Loran-C navigation system development | - | - | - | - | 183.0 | - | 170.0 | - | 353.0 |
| **Maritime Administration** | | | | | | | | | |
| (a) Precise Laser/Radar Aid to Navigation System (PLANS/PRANS) tests and development | 50.0 | 218.0 | 78.0 | 10.0 | - | - | - | - | 356.0 |
| (b) Sociological assessment questionnaire | - | - | - | 15.0 | - | - | - | - | 15.0 |
| **St. Lawrence Seaway Development Corporation** | | | | | | | | | |
| Precise All-Weather Navigation System (PAWNS) development | - | - | - | 125.0 | 30.0 | - | 700.0 | - | 855.0 |
| TOTAL - ICE NAVIGATION | 170.0 | 532.0 | 408.0 | 210.0 | 238.0 | - | 870.0 | - | 2428.0 |

| ICE CONTROL | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979(²) | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| **St. Lawrence Seaway Development Corporation** | | | | | | | | | |
| (a) Procure conceptual designs of ice control structures | $50.0 | - | - | - | - | - | - | - | $ 50.0 |
| (b) Ogdensburg-Prescott ice boom gate | - | 400.0 | 25.0 | - | - | - | - | - | 425.0 |
| (c) System Plan for All-Year Navigation (SPAN) Study | - | 200.0 | 25.0 | - | - | - | - | - | 225.0 |

TABLE IV (continued)

| ICE CONTROL (continued) | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979(²) | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| (d) Copeland Cut test ice boom | - | - | - | 280.0 | - | - | - | - | 280.0 |
| (e) Copeland Cut and Ogdensburg-Prescott ice boom model studies | - | - | - | - | 575.0 | - | - | - | 575.0 |
| (f) Galop Island ice boom modification | - | - | - | - | - | 124.0 | 176.0 | - | 300.0 |
| **Corps of Engineers - Buffalo District** | | | | | | | | | |
| St. Lawrence River activities management | - | - | 22.5 | - | - | - | - | - | 22.5 |
| TOTAL - ICE CONTROL | $50.0 | 600.0 | 72.5 | 280.0 | 575.0 | 124.0 | 176.0 | - | $1877.5 |

| ICE ENGINEERING | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979(²) | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| **Corps of Engineers - Cold Regions Research and Engineering Laboratory (CRREL)** | | | | | | | | | |
| (a) Studies and measurements of ice forces on structures - St. Lawrence River | $37.0 | $ 55.0 | $ 65.0 | $40.0 | - | - | - | - | $197.0 |
| (b) Preliminary design of Ice Engineering Modeling Facility | 10.0 | 50.0 | - | - | - | - | - | - | 60.0 |
| (c) Studies and measurements of ice forces on piles | 6.5 | 30.0 | 60.0 | - | - | - | - | - | 96.5 |
| (d) Field measurements at Lime Island air bubbler | 6.5 | - | - | - | - | - | - | - | 6.5 |
| (e) Air bubbler systems effectiveness studies | - | 20.0 | - | - | - | - | - | - | 20.0 |
| (f) Instrumenting a light structure at Toledo Harbor, Ohio | - | 10 0 | - | - | - | - | - | - | 10.0 |
| (g) St. Marys River ice boom monitoring | - | - | - | - | - | - | 28 0 | 30 0 | 58.0 |
| (h) St Marys River "Early Warning" system | - | - | - | - | - | - | 9 0 | - | 9 0 |
| (i) St Marys River vibration study | - | - | - | - | - | - | 30.0 | 20 0 | 50.0 |
| (j) Floating ice barrier effectiveness study | - | - | - | - | - | - | - | 50.0 | 50 0 |
| (k) Ice forces on marine structures | - | - | - | - | - | - | - | 100 0 | 100.0 |
| **St. Lawrence Seaway Development Corporation** | | | | | | | | | |
| Determination of forces on ice boom structure | - | 1.4 | - | - | - | - | - | - | 1 4 |
| **U.S. Coast Guard** | | | | | | | | | |
| Assist CRREL in measurement of ice forces on structures | - | 10.0 | - | - | - | - | - | - | 10.0 |
| TOTAL - ICE ENGINEERING | 60.0 | 176 4 | 125.0 | 40 0 | - | - | 67 0 | 200 0 | 668.4 |

**TABLE IV (continued)**

| ECONOMIC EVALUATION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979(1) | TOTAL |
| Economic Evaluation of Work Group activities and preparation of origin-destination traffic matrices: | | | | | | | | | |
| Corps-Detroit District and North Central Division | $2.7 | $12.4 | $10.0 | $6.6 | $1.6 | $ - | $7.1 | $12.5 | $ 52.9 |
| U.S. Coast Guard | - | - | 1.0 | - | - | - | - | - | 1.0 |
| St. Lawrence Seaway Development Corporation | - | 3.0 | 2.0 | - | - | - | - | - | 5.0 |
| Bureau of Economic Analysis | - | - | 85.0 | - | - | - | - | - | 85.0 |
| TOTAL - ECONOMIC EVALUATION | 2.7 | 15.4 | 98.0 | 6.6 | 1.6 | - | 7.1 | 12.5 | 143.9 |

| PUBLIC INFORMATION SUBCOMMITTEE | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979(1) | TOTAL |
| Preparation and issuance of public information brochures and news releases and support and coordination of public information activities | | | | | | | | | |
| Corps of Engineers - Detroit District | $ - | $40.8 | $4.5 | $ .7 | $1.3 | $ - | $15.8 | $10.0 | $73.1 |
| Great Lakes Environmental Research Labortory | - | 1.0 | 1.0 | - | - | - | - | - | 2.0 |
| U.S. Coast Guard | - | .4 | 1.0 | .3 | - | - | - | 1.0 | 2.7 |
| St Lawrence Seaway Development Corporation | - | 1.0 | .4 | 1.0 | - | - | 1.0 | 1.0 | 4.4 |
| Maritime Administration | - | 1.0 | - | 1.0 | - | - | 1.0 | - | 3.0 |
| Environmental Protection Agency | - | - | - | 1.0 | - | - | 1.0 | 1.0 | 3.0 |
| Cold Regions Research and Engineering Laboratory | - | 1.0 | 1.0 | 1.0 | - | - | 1.0 | 1.0 | 5.0 |
| TOTAL - PUBLIC INFORMATION | - | 45.2 | 7.9 | 5.0 | 1.3 | - | 19.8 | 14.0 | 93.2 |

TABLE IV (continued)

| ENVIRONMENTAL EVALUATION | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979(³) | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| Coordination and Review of Environmental Data Collection, EIS's and Evaluation of Individual Work Group Activities: | | | | | | | | | |
| Environmental Protection Agency | $ 4.0 | $13.5 | $ 18.6 | $ 20.0 | $ 24.0 | $ 5.0 | $ 26.0 | $ 26.0 | $ 137.1 |
| U.S. Fish and Wildlife Service | 10.0 | 41.0 | 26.0 | 26.0 | 35.0 | - | 28.6 | 26.0 | 192.6 |
| Bureau of Outdoor Recreation | 8.0 | 20.0 | 14.0 | 14.0 | 23.0 | 4.7 | - | - | 83.7 |
| U.S. Coast Guard | - | .3 | 4.0 | .3 | 19.0 | - | 4.6 | 9.0 | 37.2 |
| Great Lakes Environmental Research Laboratory | 2.0 | 5.0 | 4.0 | 4.0 | 4.4 | - | 5.0 | 4.0 | 28.4 |
| Corps of Engineers- Detroit District | - | 7.0 | 14.1 | 12.1 | 18.6 | 3.1 | 43.8 | 13.5 | 112.2 |
| St. Lawrence Seaway Development Corp. | - | - | - | - | - | - | 20.0 | 16.5 | 36.5 |
| Maritime Administration | - | - | - | - | - | - | 1.0 | - | 1.0 |
| **U.S. Fish and Wildlife Service** | | | | | | | | | |
| (a) Fish Study and Turbulence Effects on Shallow Water Sediment and Organisms | - | - | - | 42.0 | - | - | - | - | 42.0 |
| (b) Coordinate Demonstration Activities and relate to total system investigated by the Survey Study | - | - | - | - | 17.5 | - | - | - | 17.5 |
| (c) Study of distribution and abundance of macrobenthos, lower St. Clair River | - | - | - | - | - | - | 21.0 | - | 21.0 |
| **St. Lawrence River Environmental Study** | | | | | | | | | |
| U.S. Fish and Wildlife Service | - | - | - | - | - | 70.0 | 225.0 | - | 295.0 |
| St. Lawrence Seaway Development Corp. | - | - | - | - | 199.0 | - | - | - | 199.0 |
| Bureau of Outdoor Recreation | - | - | - | - | 16.0 | - | - | - | 16.0 |
| **Corps of Engineers - St. Paul District** | | | | | | | | | |
| Bubbler system, Duluth-Superior Harbor | - | 8.0 | 30.0 | - | - | - | - | - | 38.0 |
| **Great Lakes Basin Commission** | | | | | | | | | |
| (a) Environmental studies coordinator and Environmental Monitoring Plan refinement | - | - | - | - | - | - | - | 30.0 | 30.0 |
| (b) Evaluation of benthic dislocation due to an induced wave in an ice environment | - | - | - | - | - | - | - | 10.0 | 10.0 |
| (c) Effects of winter navigation on waterfowl and raptorial birds, St Marys River | - | - | - | - | - | - | - | 20.0 | 20.0 |

**TABLE IV (continued)**

| ENVIRONMENTAL EVALUATION | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979(2) | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| (d) Effects of ship induced waves in an ice environment on the St. Marys River ecosystem | - | - | - | - | - | - | - | 58.0 | 58.0 |
| (e) Ship induced waves - ice and physical measurements on the St. Marys River | - | - | - | - | - | - | - | 22.0 | 22.0 |
| (f) Fisheries study | - | - | - | - | - | - | - | 60.0 | 60.0 |
| (g) Analysis of control sites (Paired Sites) glaciological and limnological portion | - | - | - | - | - | - | - | 85.0 | 85.0 |
| (h) Comparative study - St Marys and St. Lawrence Rivers | - | - | - | - | - | - | - | 23.1 | 23.1 |
| (i) Waterfowl, waterbirds, and raptors, St. Lawrence River | - | - | - | - | - | - | - | 44.3 | 44.3 |
| TOTAL - ENVIRONMENTAL EVALUATION | 24.0 | 94.8 | 110.7 | 118.4 | 356.5 | 82.8 | 375.0 | 447.4 | 1609.6 |

| PROGRAM MANAGEMENT | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979(2) | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| **Corps - Detroit District and North Central Division** | | | | | | | | | |
| Travel, reproduction, report preparation, payroll, organization, scheduling, planning and design costs for overall management of Demonstration Program | $111.3 | $ 181.4 | $ 192.5 | $ 216.3 | $ 343.2 | $ - | $ 140.0 | $ 260.0 | $ 1,444.7 |
| **St. Lawrence Seaway Development Corporation** | | | | | | | | | |
| Technical Review Panel review of Demonstration Program activities | - | - | - | 30.0 | - | - | - | - | 30.0 |
| TOTAL - PROGRAM MANAGEMENT | 111.3 | 181.4 | 192.5 | 246.3 | 343.2 | - | 140.0 | 260.0 | 1,474.7 |
| Reallocation to survey study | - | - | - | - | - | - | - | - | 187.8 |
| TOTAL - Allocated or expended Demonstration Program funds | 744.0 | 2,374.0 | 1,547.5 | 1,828.4 | 2,645.1 | 361.0 | 2,300.0 | 1,868.0 | 13,668.0 |
| TOTAL - Accumulated Funds Allotted | 744.0 | 3,118.0 | 4,665.5 | 6,493.9 | 9,139.0 | 9,500.0 | 11,800.0 | 13,668.0 | |
| TOTAL - Accumulated Expenditures | 744.0 | 3,022.0 | 4,616.4 | 6,386.2 | 9,137.4 | 9,489.2 | 11,972.7 | 13,668.0 | |

*Coast Guard Cutter at work.*

*General cargo study*

In April of 1974 the Bureau of Economic Analysis completed for the Winter Navigation Board a study entitled; "Extending the Great Lakes-St. Lawrence Seaway Shipping Season: The Economic Effects on General Cargo and Related Industries." The purpose of this study was to evaluate the economic impact of general cargo movements and the further direct, indirect, and induced economic effects on an eleven state study area, as a consequence of extending the shipping season on the Great Lakes-St. Lawrence Seaway. The eleven state region consisted of Ohio, Michigan, Indiana, Illinois, Wisconsin, Minnesota, Iowa, Nebraska, South Dakota, North Dakota, and Wyoming.

The evaluation was based on (1) primary-impact, transport-sensitivity model, (2) a secondary economic impact model, and (3) preliminary aggregate estimates of the total economic impact on the study area as a whole. Further refinement of the models which was planned for a second phase of the study was not conducted. The approach used avoids the confusion of benefits due to other public and private investments which would have occurred without season extension, with those due solely to season extension.

The study indicated the study area as a whole has been growing at a rate somewhat slower than the Nation in recent history and the season extension program, with respect to general cargo movements, would offset part of this relative decline, particularly in the manufacturing states in the study area. Information aquired during the study was used in preparation of the survey study.

*Work group cost data*

The cost data compiled from each work group consisted of the material, installation, operation, and maintenance costs associated with a given work activity. In addition, data on the effectiveness of various activities were obtained. The cost and effectiveness data, which were collected during the Demonstration Program have been evaluated and will be utilized to insure that the most cost-effective measures tested during the Demonstration Program will be selected for use in any plans of improvement to extend the navigation season. The total costs of specific FY 72-FY 79 Demonstration Program activities, by work group and by expenditures, chargeable to various items are depicted in Table IV. The FY 79 funds are estimated costs pending financial closeout.

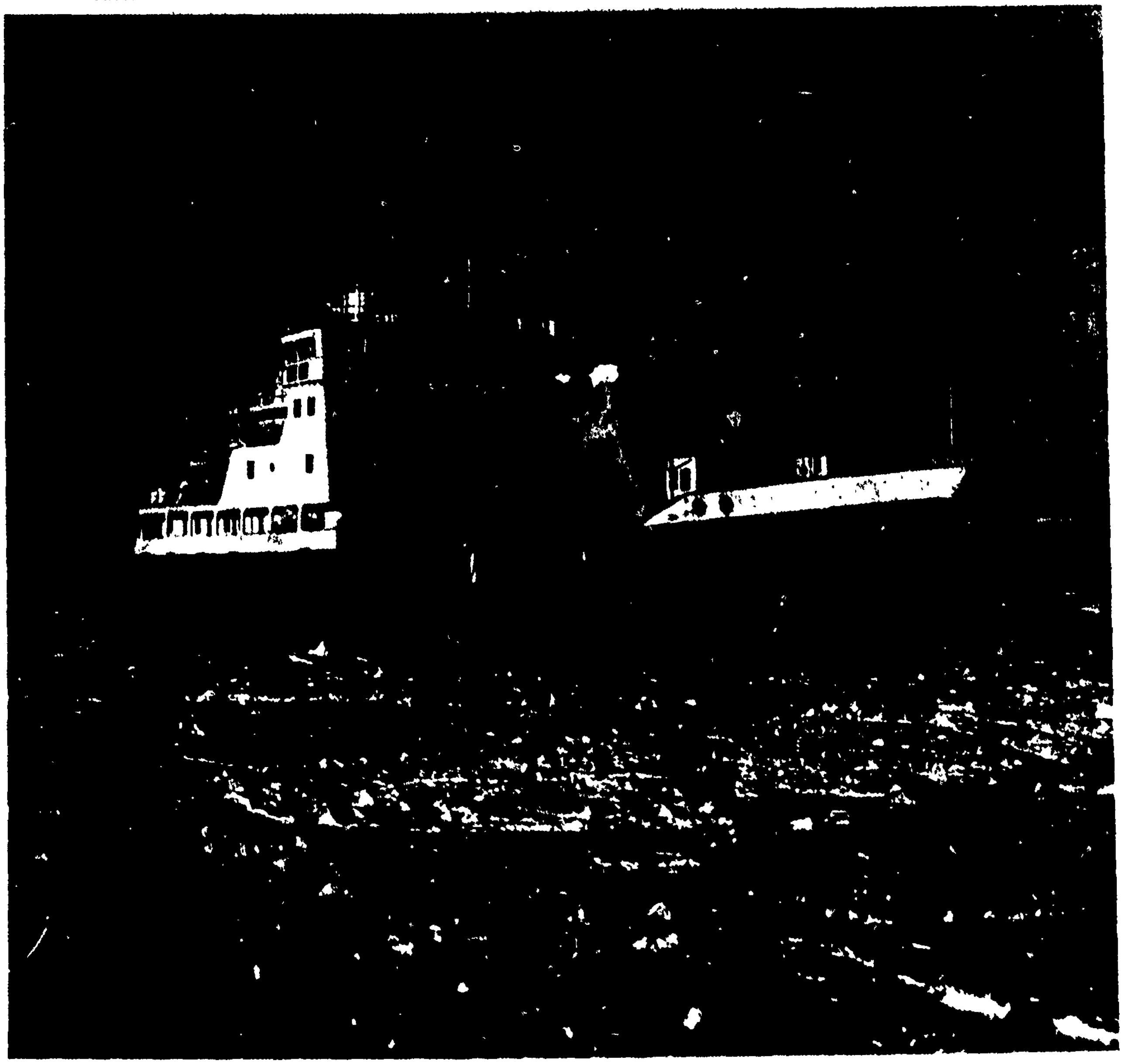
## Canadian co-participation

The Canadian Government has not, as of this writing, issued a formal statement regarding their position concerning an extended navigation season. There has been, however, informal cooperation between various agencies of both governments in an effort to keep the Canadian Government informed about an issue of concern to both neighboring countries.

*Winter Navigation Board and Working Committee*

In an observer status, Canadian representation throughout the Demonstration Program has been present on both the Winter Navigation Board and the Working Committee. The St. Lawrence Seaway Development Corporation has worked closely with its operational Canadian counterpart, The St. Lawrence Seaway Authority, and the Canadian Marine Transportation Administration.

*The Canadian* Griffon *breaks ice in the St Marys River*



*Winter navigation from Montreal to the Atlantic Ocean*

There is currently navigation year-round from the Atlantic Ocean as far as Montreal on the St. Lawrence River. In addition to conventional icebreakers the Canadians have used on an operational basis a self-propelled air cushion vehicle, both for icebreaking and flood control purposes

*Canadian Coast Guard air cushion vehicle, Voyageur, in action.*

The Canadian Marine Transportation Administration, Ministry of Transport, has prepared Annual Reports on data collection on the Great Lakes-St. Lawrence Seaway System. Included in these reports are studies on ice coverage and conditions as observed both from their icebreaking research vessels and from aerial fly-overs. In addition, the Canadians documented ice thickness, shore observations, hydrometeorological data, icebreaking operations and operational problems as they occurred The data collected are intended to be compared with past and possibly future studies pertaining to an extension of the navigation season.

*Bow mounted air cushion vehicle,* Iceater, *tests.*

*Joint U.S.-Canadian Icebreaking Guide*

The U.S. and Canadian Coast Guards cooperated in the publication of a *Joint U.S. Coast Guard-Canadian Coast Guard Guide to Great Lakes Ice Navigation* to coordinate the standardized ice navigation activities. The guide summarizes information available to shippers with regard to communication and reporting procedures for ships leaving ports, up-to-date ice chart broadcasts, weather forecasts and winter navigation data transmitted periodically by the Ice Navigation Center. Advice and requirements for ships operating in ice both independently and with icebreaker support is supplied in the publication as well. The guide also provides a summary of anticipated ice conditions through the Great Lakes.

*Seaway Corporation/Seaway Authority coordination*

The two Seaway entities, the St. Lawrence Seaway Development Corporation of the United States and the St. Lawrence Seaway Authority of Canada are authorized by their respective enabling legislation to coordinate their activities directly. Season extension coordination between the entities has proceeded under this same authority. One example of coordination includes the frequent meetings between the entities each year to reach agreement on navigation season closings and openings. In addition, a joint SLSDC/SLSA task group on navigation season extension coordinates study efforts and data exchange and proposes joint, in-house programs for incremental extensions. Finally, Seaway Authority representatives have participated as observers on the Ice Control Work Group (chaired by SLSDC) and the Ad Hoc Committee on St. Lawrence River Demonstration Activities (chaired by NOAA-GLERL).

## Public Involvement

*St. Marys River Operational Plan*

Near the end of each year at Sault Ste. Marie, Michigan, participating agencies, organizations, governments and businesses with a common interest in the St. Marys River Demonstration Program meet to look ahead at the coming year. The purpose of the meeting is to develop a plan which will allow the St. Marys River system to function as normally as possible and at the same time to allow commercial navigation to continue as long as possible into the winter season.

Primary elements in the planning involve provisions for the transportation of inhabitants for the four major islands in the area and for icebreaking activity. Also included in the procedure are steps for the halting of ship traffic in the system should island transportation be jeopardized. At the conclusion of the annual meeting, a press conference is held to provide concerned local residents with information relating to the coming year. In FY 78 the meeting was followed by a public meeting to permit area residents to discuss their views.

*Public meetings and workshops*

Public involvement in the planning process is a vital key to public acceptance and to the eventual implementation of a plan. Public meetings and public workshops are two methods of achieving effective involvement.

Public meetings were established to inform the public about studies and proposals relating to the winter navigation program and to provide an informal arena for the exchange of views and pertinent information. The workshops, on the other hand, functioned in a small, less structured format in which mixed interested groups discussed issues and recommended problem solutions

On 17 February 1973 a public meeting was held at St. Ignace, Michigan. As the result of a Congressional inquiry the Detroit District Engineer attended as a representative of the Winter Navigation Board. The meeting was scheduled with residents of Drummond Island, Chippewa County officials, the U.S. Coast Guard, and the U.S. Army Corps of Engineers to hear complaints from area residents on Drummond Island concerning interruption of ferry service allegedly resulting from the extended navigation season. The meeting resulted in a study of conditions at Drummond Island which concluded that Winter Navigation had no effect on Drummond Island ferry operations.

A public workshop was held in July 1975 at Sault Ste. Marie, Michigan, to obtain public views, ideas and concerns regarding the effects and problems relating to the safe management of shorelines affected by winter vessel transits. The workshop also included the presentation of the results of a study conducted in 1974 on the effects of winter navigation to this shoreline.

A public meeting was also held January 1977 at the Soo to obtain public needs and viewpoints relative to the navigation season extension survey and the Demonstration Program. Concepts dealing with the

future directions of both the Survey and the Demonstration Program were presented to the public in Cleveland in October 1977.

On 1 August 1978 a public meeting was held in Alexandria Bay, New York. The purpose of the meeting was to inform the residents of the St. Lawrence River of the preparations the Winter Navigation Board proposed for the demonstration on the St. Lawrence River for the winter of 1978-79 and to answer their questions relating to those plans.

*Winter Navigation Board and Working Committee meetings*

Throughout the eight years of the program 32 Board meetings and 42 Working Committee meetings have been held at various locations on the Great Lakes-St. Lawrence Seaway system. At these meetings the various involved agencies discuss the progress and goals of Winter Navigation activities. The meetings are open to the public and members of the public are allowed to provide formal statements on their views.

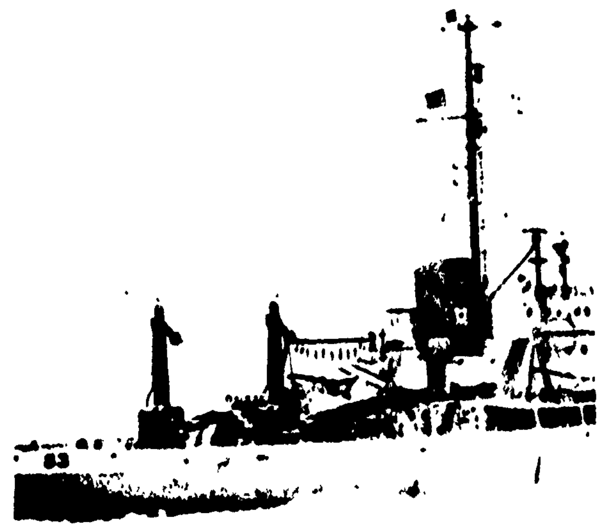
*Public opinion*

The Demonstration Program and Survey Study are separate and distinct. Each has a separate function as described in the authorizing legislation.

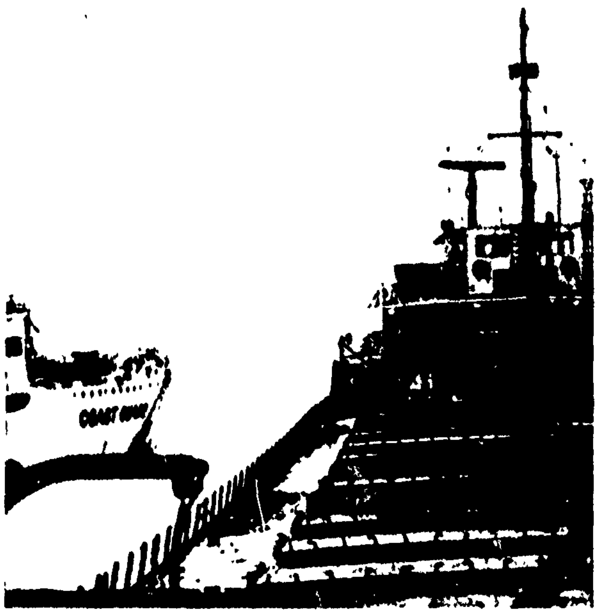
Potential impacts which may result from an extended navigation season have made season extension on the Great Lakes and St. Lawrence Seaway System a controversial issue. Public involvement activities have served to highlight these concerns.

Governmental, organizational, and individual environmental concerns have raised objections to the extension of the season. Opposition has also been voiced by others, including the State of New York, the New York Department of Environmental Conservation (NYDEC), hydroelectric power entities (Power Authority of the State of New York, Soo Edison), sport groups, and tourism concerns. Riparians, affected island residents, freight railroads, and coastal zone management agencies have raised issues of concern. Certain Congressmen and some trade unions as well as some private citizens are opposed to the extension of the navigation season.

*Coast Guard Cutter at work.*



Those who are in favor of the season extension of the System include industrial interests, including those of steel, grain, power, coal, petroleum and mining, domestic and foreign shippers (import and export) and ship owners and operators. The St. Lawrence Seaway Authority and several Port Authorities support the program. Proponents also include some Congressmen and trade unions and some private citizens. The State of Michigan has issued a statement supporting a modest, yet flexible, extension on the upper four Great Lakes, provided a number of environmental, economic, and operational conditions are met.



Others have expressed concern, but remain uncommitted at this writing. The States of Wisconsin, Minnesota, Illinois, Indiana, Ohio, Pennsylvania, and the Government of Canada have not issued formal statements regarding their position.

The controversy with navigation season extension is based on a number of issues.

Agencies with environmental expertise and responsibilities and environmentalists point out potential damage to natural resources (fisheries, wildlife, etc.), and possible adverse effects of dredging. The results of an environmental assessment (NYDEC) indicated irreversible adverse effects to the environment due to the Demonstration Program.

Potential shore erosion and shore structure damage are a major issue of contention. The threat of oil and hazardous substance spills, possible changes to levels and flows in the system, and cross-channel transportation (island-mainland), are also issues. Private industry and governmental agencies have questioned whether water intakes and sewer outflows will be affected by projected water levels in the program.

Tourism, railroad concerns, and riparians have raised/brought up the matter of potential economic losses of season extension. Social problems involve port personnel (schedules, safe working conditions) and recreation (ice fishing, snowmobiling, etc.). Power entities question the liability regarding flooding, and the potential problems of winter navigation though ice booms, which are installed to provide a stable ice cover above generating plants.

### *Winter Navigation Seminar*

In December 1973, the Department of the Army sponsored a Great Lakes and St. Lawrence Seaway navigation seminar at Detroit. The purpose of the seminar was to furnish the public with further information regarding the winter navigation program and to provide a forum for the expression of views and discussion by all parties with an interest in the program.

### *Public Information Brochures*

Another effective means of public involvement is the use of concise information publications. During the first two years of the program, two fact sheets were [illegible]d, stating the purpose of the program and [illegible] for program activities. In May 1978, the publication, *Winter Navigator* was put out by the Public Involvement Sub-Committee.


CONNECTICUT

*Great Lakes tug assists carrier.*

# PART IV: FINDINGS AND CONCLUSIONS

*Findings: The overall finding during the eight years of the Demonstration Program is that the traditional navigation season on the Great Lakes-St. Lawrence Seaway System has been successfully extended.*

Commercial navigation has successfully been extended beyond the historic closing date of 16 December on the upper four Great Lakes and connecting channels during every year of the program. Year-round shipping was achieved during the latter five years. On the St. Lawrence River, where historically the season extended from mid-April to early December, the longest commercial season in history was recorded in 1975 with a 25 March opening and a 20 December closing

As discussed in the following paragraphs, specific findings resulted from Demonstration Program activities in the areas of ship movement through ice, navigation aids, ice and weather information, crew safety and survival, ice control, and island transportation. In addition, under an ongoing program, year-round lock operation was demonstrated.

*1. Movement of vessels through winter ice conditions was demonstrated*

The use of preventative icebreaking and the use of ship convoys were useful tools in moving vessels through ice. The use of air bubbler systems and a thermal ice suppression system were both effective in melting or reducing ice cover and easing vessel movement through areas of stable ice cover. The air bubbler systems also allowed vessels to maneuver in confined areas of the Duluth-Superior Harbor. The bubbler system at the Lime Island Turn in the St. Marys River showed the practicability of this type of system in reducing ice thicknesses in a river and demonstrated its use in aiding the turning of the long lake vessels.

*2. Navigation aids suitable for use in varying ice and weather conditions were only partially successful.*

Specially designed ice buoys for use under ice conditions showed some success, but due to their limited utility, emphasis was placed on developing various electronic navigation systems. A mini-Loran C navigation system was used on the St. Marys River, but its accuracy within narrow channels has not yet been demonstrated. A Precise All Weather Navigation System (PAWNS) was not fully demonstrated during the program. Radar transponder beacons (RACONS) successfully extended the range and utility of shipboard radar units

*3. Weather and ice information are required by vessel operators for safe transit through the system.*

Weather and ice information was disseminated by a special Ice Navigation Center at the Ninth Coast Guard District Headquarters in Cleveland, Ohio in coordination with the National Weather Service. Aerial reconnaissance and Side-Looking Airborne Radar (SLAR), were sucessfully used as inputs to the ice information portion of the program. The aerial

*SLAR image of Lake Erie.*

reconnaissance and SLAR provided real-time information on the extent of ice cover. Methods of providing both long and short range ice forecasts for all areas of the Great Lakes were developed by the National Oceanic and Atmospheric Administration. Ice forecast services are furnished by National Weather Service Forecast offices in Ann Arbor, Michigan, and Buffalo, New York. A model was developed to predict the ice breakup period in the St. Lawrence River. The ice breakup forecast technique is used to allow advance scheduling of ocean trade vessels into the system.

*4. Crew safety and survival can be aided by tested and approved survival equipment.*

Crew safety and survival in an extended season were given considerable attention. The Coast Guard field tested and evaluated a variety of personnel exposure suits and survival equipment. Several types of exposure suits have been approved for use by shippers by the Coast Guard Emergency Position Indicating Radio Beacons (EPIRBs) and hand held radar transponders have shown effectiveness in pinpointing the location of both ships and personnel, enhancing the efficiency of search and rescue operations.

*5. Ice control structures can be designed to permit navigation through them while maintaining a stable ice cover and minimizing ice jams.*

Ice jams in constricted portions of the system, especially the St. Marys, St. Lawrence, and St. Clair Rivers, can prevent the passage of all but a few vessels with substantial ice operating capabilities The jams also cause flooding problems and in some cases reduce the flow of water to power plants and municipal intakes. The annual installation of a navigation ice boom and other structures at the head of Little Rapids Cut in the St. Marys River allowed vessel movement to continue year-round during four of the last five years of the program with no major ice problems occurring. Similar, but limited, demonstrations were conducted at Copeland Cut in the St. Lawrence River with the same results. Model studies were conducted in FY 79 to determine the type and effectiveness of ice control structures needed at the head of the St. Clair River.

*6. Operations at the locks at Sault Ste. Marie, Michigan, demonstrated that year round lock operations are possible.*

Under ongoing investigations, systems for winterizing lock operating machinery were successfully demonstrated. The use of co-polymer coatings and steamlines were effective in removing ice from lock walls. A bubbler system and air curtain were effective in keeping floating ice out of gate recesses and limiting the amount of ice entering locks. Protective housing and the use of heated cables helped prevent ice buildup on lock gate machinery.

*7. Extended season navigation has the potential to contribute to shore erosion problems and increased damage to docks.*

Studies conducted during the program have indicated that winter navigation has the potential to contribute to increased shore erosion and damage to docks in limited areas of the connecting channels including the St Marys, St. Clair and St. Lawrence Rivers. Further investigation is required to distinguish between that damage occuring below the ordinary high water mark which is caused by ship movement in ice and that caused by natural ice movement.

*8. Transportation for island residents can be maintained while permitting navigation through the area.*

To test means of improving the ice operating capabilities of the Sugar Island ferry, several modifications were made to its hull and power com-

ponents. These modifications enabled the ferry to operate in moving ice floes. The installation of the St. Marys River ice boom above Little Rapids Cut reduced the amount of ice moving down the Cut, further increasing the ferry's capabilities. Additionally, the installation of an air bubbler-flusher unit at the Sugar Island ferry mainland dock, to create a surface current to physically flush ice away from the dock, enabled the ferry to land more easily. An airboat was utilized at Lime Island to provide transportation for the residents of that Island. During the program, several improvements were made to the airboat but the residents have expressed dissatisfaction with this form of transportation.

*9. Unresolved questions precluded actual demonstration of extended commercial navigation on the St. Lawrence River.*

The upper four Great Lakes and their connecting channels are significantly different, both physically and administratively, from the lower portion of the system.

On the upper four Great Lakes, the program was carried out essentially in the United States waters and did not require co-participating involvement of Canada. In the St. Lawrence Seaway, activities were in the waters of both Canada and the United States and could not be implemented to the same extent, that is including full vessel tests and similar winter operations, without substantial improvements in the all-Canadian portion of the St. Lawrence River. In addition, opposition by power entities initially delayed Demonstration Program execution on the St. Lawrence Seaway portion of the system.

The Board under these circumstances stressed operation on the upper four Great Lakes in order to obtain prototype information and delayed such tests in the St. Lawrence River towards the end of the program in the belief that sufficient technical data would be acquired in the course of the program to allow resolution of the questions raised by local interests and New York State. Strong opposition by local interests, including the State of New York, finally precluded full Demonstration Program execution on the St. Lawrence Seaway portion of the system.

In their 1976 report the Board requested that in view of these circumstances on the St. Lawrence Seaway, Congress provide two additional years and appropriate funding to carry out the St. Lawrence Program including vessel tests. This funding and authority were provided, but the issues could not be resolved and comprehensive vessel tests were never carried out.

*10. Sufficient data on the effects of extended season navigation on the Great Lakes environment are not currently available.*

A limited number of environmental studies have been conducted on some of the demonstration program activities. While this does not comprise a complete analysis, adverse impacts to the environment have not been documented in the areas that have been investigated. Several baseline studies have been accomplished but they are not sufficient to make judgments as to the long range effects of the program. The New York Department of Environmental Conservation has completed a study for the Winter Navigation Board indicating irreversible adverse effects to the environment would occur and partially base their objection to the program on that study.

*Conclusions: The overall conclusion is that the practicability of navigation season extension on the upper four lakes of the Great Lakes-St. Lawrence Seaway system has been successfully demonstrated.*

The eight years of the demonstration program have shown that technically an extension of the traditional navigation season is practicable. Several issues still need to be resolved before a permanent season extension could be implemented.

1. Before the practicability of winter navigation in the St. Lawrence River can be determined, it must be demonstrated that certain existing ice control structures and related ice fields can be safely transited without disrupting the integrity of the ice fields and adversely affecting regulated water levels and flows of the river.

2. Significant amounts of environmental baseline data need to be collected to establish parameters against which to evaluate the extended season activities and to form part of the basis for measures and practices that may be necessary to protect the natural resources of the system.

3. The United States Government needs to seek appropriate Canadian participation in future extended season activities. Their participation is essential before overseas commercial shipping in the system can be extended.

*Aerial shows winter operation at U.S. Seaway lock.*

# V. THE FUTURE

The concept of a Demonstration Program, as envisioned by the Congress in the authorizing legislation, has provided a unique and invaluable opportunity for determining the problems, identifying the issues and testing site specific solutions for extended season navigation on the Great Lakes and St. Lawrence Seaway navigation system. In final perspective, the Program has significantly increased the understanding of the winter environment and its complexity - and - has measurably advanced the state-of-the-art of ice navigation.

The Program has also had as an objective the need to provide to Congress, and to bring to all interests, a timely and meaningful overview of the possibility of safe and practical year-round navigation on the Fourth Seacoast of the United States. In this objective it has provided the opportunity for industry, labor and interested society in general to examine, to investigate and to evaluate the issues and potential benefits and costs of winter navigation. This in itself, while fostering questions and controversy, has been a continuing measure of the importance and value of the enabling legislation.

This Demonstration Program Final Report does not contain recommendations concerning implementation of a navigation season extension. However the results and conclusions obtained over the span of eight years covered by the program are being used for formulating future plans, programs and recommendations to Congress under the survey study authority of Section 107(a), Public Law 91-611, of the 1970 River and Harbor Act.

Section 107(a) provides for a survey study to determine the feasibility of means of extending the navigation season on the Great Lakes and St. Lawrence Seaway System and to determine the extent of Federal interest, if any, in an extended navigation season. The Final Report for the survey study is currently being prepared by the U.S. Army Corps of Engineers and is scheduled to be released to the public on 31 December 1979 upon issuance of the Division Engineer, North Central Division, notice. The Final Report would then be forwarded to the Chief of Engineers office for Washington level review and coordination prior to submittal of the report to the Congress.

# Authority

**1970 River and Harbor Act (PL 91-611, December 31, 1970).**

*SECTION 107, River and Harbor Act of 1970*

*(a) The Secretary of the Army, acting through the Chief of Engineers, is authorized to conduct a survey of the Great Lakes and St. Lawrence Seaway to determine the feasibility of means of extending the navigation season in accordance with the recommendations of the Chief of Engineers in his report entitled "Great Lakes and St. Lawrence Seaway--Navigation Season Extension".*

*(b) The Secretary of the Army, acting through the Chief of Engineers, in cooperation with the Departments of Transportation, Interior, and Commerce, including specifically the Coast Guard, the St. Lawrence Seaway Development Corporation, and the Maritime Administration; the Environmental Protection Agency; other interested Federal agencies, and Non-Federal public and private interests, is authorized and directed to undertake a program to demonstrate the practicability of extending the navigation season on the Great Lakes and St. Lawrence Seaway. Such a program shall include, but not be limited to, ship voyages extending beyond the normal navigation season; observation and surveillance of ice conditions and ice forces, environmental and ecological investigations; collection of technical data related to improved vessel design; ice control facilities, and aids to navigation; physical model studies; and coordination of the collection and dissemination of information to shippers on weather and ice conditions. The Secretary of the Army, acting through the Chief of Engineers, shall submit a report describing the results of the program to the Congress not later than July 30, 1974. There is authorized to be appropriated to the Secretary of the Army not to exceed $6,500,000 to carry out this subsection.*

*(c) The Secretary of Commerce, acting through the Maritime Administration, in consultation with other interested Federal agencies, representatives of the merchant marine, insurance companies, industry, and other interested organizations, shall conduct a study of ways and means to provide reasonable insurance rates for shippers and vessels engaged in waterborne commerce on the Great Lakes and the St. Lawrence Seaway beyond the present navigation season, and shall submit a report, together with any legislative recommendations, to Congress by June 30, 1971."*

**Water Resources Development Act of 1974 (PL 93-251, March 7, 1974).**

*Sec. 70. Section 107(b) of the River and Harbor Act of 1970 (84 Stat. 1818, 1820) is hereby amended by deleting "July 30, 1974" and inserting in lieu thereof "December 31, 1976", and deleting "$6,500,000" and inserting in lieu thereof "$9,500,000."*

**Water Resources Development Act of 1976 (PL 94-587, October 22, 1976),**

*Sec. 107. Section 107(b) of the River and Harbor Act of 1970 (84 Stat. 1818, 1820), as amended, is further amended by striking out "December 31, 1976" and inserting in lieu thereof "September 30, 1979" and striking out "$9,500,000" and inserting in lieu thereof "$15,968,000". Such section 107(b) is further amended in the second sentence thereof by striking out "environmental and ecological investigation;" and inserting in lieu thereof "environmental and ecological investigations, including an investigation of measures necessary to ameliorate any adverse impacts upon local communities;"*

# MEMORANDUM OF UNDERSTANDING

**Great Lakes and Saint Lawrence Seaway Navigation Season Extension Demonstration Program**

**Between**

**U.S. Army Corps of Engineers**
**Maritime Administration**
**U.S. Coast Guard**
**St. Lawrence Seaway Development Corporation**
**National Oceanic & Atmospheric Administration**
**Environmental Protection Agency**
**Department of the Interior**
**Federal Power Commission**

1. This Memorandum of Understanding prescribes the organization and procedures for managing, coordinating and reporting on the program authorized by Section 107(b) of Public Law 91-611 to demonstrate the practicability of extending the navigation season on the Great Lakes and Saint Lawrence Seaway. It covers the Federal agencies participating in the program and their relations with other program participants.

2. AUTHORIZATION

Section 107(b) of the 1970 Rivers and Harbors Act (P.L. 91-611) provides.

"The Secretary of the Army, acting through the Chief of Engineers, in cooperation with the Departments of Transportation, Interior, and Commerce, including specifically the Coast Guard, the Saint Lawrence Seaway Development Corporation, and the Maritime Administration; the Environmental Protection Agency; other interested Federal agencies, and non-Federal public and private interests, is authorized and directed to undertake a program to demonstrate the practicability of extending the navigation season on the Great Lakes and Saint Lawrence Seaway. Such program shall include, but not be limited to, ship voyages extending beyond the normal navigation season; observation and surveillance of ice conditions and ice forces; environmental and ecological investigations; collection of technical data related to improved vessel design; ice control facilities, aids to navigation; physical model studies; and coordination of the collection and dissemination of information to shippers on weather and ice conditions. The Secretary of the Army, acting through the Chief of Engineers, shall submit a report describing the results of the program to the Congress not later than July 30, 1974. There is authorized to be appropriated to the Secretary of the Army not to exceed $6,500,000 to carry out this subsection."

3. ORGANIZATION

The demonstration program will be carried out by elements of the Federal Government, other public agencies, and private entities as prescribed by law. The organization for management, coordination and reporting will be as shown on the chart in Inclosure #1.*

*Lead Agencies.* The investigation and demonstration activities under the program will be divided initially into seven program elements. One of the Federal agencies will be responsible as lead agency for execution of each program element, in accordance with the program assignments shown in Inclosure #1.* Each lead agency will carry out its element of the program with its own forces, with support from other govern-

*Organization chart is shown on page 30 of this report.

ment agencies, and by contract at its own discretion. The lead agency for each program element will form and chair a work group of representatives of all agencies participating in that program element, in order to establish definite points for coordination of program participation.

*Board.* A Board of senior field representatives of the participating Federal agencies and invited non-Federal public and private interests will coordinate planning, programming, budgeting, execution and reporting of investigations and demonstration activities. The Division Engineer, North Central Division, Corps of Engineers, will serve as Chairman of the Board. Board members will forward coordinated recommendations to their respective headquarters in Washington, where they will receive normal departmental review and interdepartmental coordination before transmittal by the Secretary of the Army to the Office of Management and Budget and the Congress.

*Working Committee.* A Working Committee of representatives of participating Federal agencies and invited non-Federal public and private interests will provide continuous coordination of program activities and will develop and coordinate plans, programs, budgets, schedules, work descriptions, and reports for consideration by the Board. The District Engineer, Detroit District, Corps of Engineers, will serve as Chairman of the Working Committee.

*Advisory Group.* An advisory group will be formed to provide broad representation from private interests in the planning and execution of the demonstration program. The Advisory Group will include representatives of industry, labor, consumers, and concerned citizens. The Advisory Group will name two of its members to serve on the Board and two representatives to serve on the Working Committee. Such representatives will serve on the Board and Working Committee for terms of one year and may be named to successive terms at the discretion of the Advisory Group. The Board and the Working Committee will consult the Advisory Group to obtain proposals for demonstration activities, recommendations on the conditions under which extended season navigation should be carried out, and the results of the demonstration program each year for all affected private interests.

## 4. FUNDING

Funding of investigations and demonstration activities will be both by appropriations under authority of Section 107(b), PL 91-611, and by separate appropriations of the various participating agencies and interests. The Working Committee will assemble a coordinated budget showing the agency requests for funds from demonstration program appropriations and the amounts which agencies propose to expend from their own separate appropriations for activities directly related to the demonstration program. The preparation of a coordinated budget is not intended to infringe on any agency's freedom to use its own funds, but justification of requests to Congress for appropriations must be based upon a full revelation of the various sources of funds supporting the total program.

The Board will review the coordinated budget request and forward its recommendation to the Office of the Chief of Engineers for incorporation in the Corps of Engineers civil works budget. Other agencies may defend their separate appropriations for demonstration activities based upon the budget recommendations of the Board.

Demonstration program appropriations will be allocated to participating agencies in accordance with the recommendations of the Board. Upon apportionment by the Office of Management and Budget, the funds for the demonstration program appropriated under the authority of Section 107(b), PL 91-611, will be allotted to the Detroit District by the Office of the Chief of Engineers. The District Engineer, Detroit District will furnish to each lead agency a reimbursable agreement in the amount approved by the Board. Reimbursement for expenditures will be based on billings from each lead agency to the Detroit District.

## 5. PUBLIC INFORMATION

Success of the demonstration program depends upon an effective public information program to explain the objectives and the issues involved in extension of the navigation season on the Great Lakes and the Saint Lawrence Seaway. The Working Committee will serve as the means of coordinating public information activities of all program participants, subject to policy guidance from the Board. Each agency represented on the Working Committee will advise the Chairman of the Working Committee when his agency proposes making public announcements or undertaking other significant public information activities related to the demonstration program. The Working Committee Chairman will notify the other agency representatives of such announcements or activities, for their advance information.

Public meetings for the purpose of public participation in the demonstration program will be conducted jointly by the participating agencies under the policy guidance of the Board.



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U.S. ARMY CORPS OF ENGINEERS

NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION

MARITIME ADMINISTRATION

ENVIRONMENTAL PROTECTION AGENCY

Francis T. Mayo

March 28, 1972

U.S. COAST GUARD

C R Bender

DEPARTMENT OF THE INTERIOR

March 16, 1972

SAINT LAWRENCE SEAWAY DEVELOPMENT CORPORATION

D W Oberlin

March 23, 1972

FEDERAL POWER COMMISSION

T A Phillips

# PARTICIPATING AGENCIES

United States Army Corps of Engineers

St. Lawrence Seaway Development Corporation

United States Coast Guard

National Oceanic and Atmospheric Administration

Maritime Administration

U.S. Department of the Interior

Great Lakes Basin Commission

Great Lakes Commission

Environmental Protection Agency

Federal Energy Regulatory Commission

TECHNICAL ADVISORS: National Aeronautics and Space Administration (NASA) and
Energy Research and Development Administration (ERDA)

ADVISORY GROUP: Industry/Labor

OBSERVERS: Saint Lawrence Seaway Authority of Canada
Canadian Coast Guard
International Joint Commission
U.S. Department of State

# APPENDIX L

## REFERENCE LIST, GLOSSARY, AND ABBREVIATIONS

AUGUST 1979

# APPENDIX L

# REFERENCE LIST, GLOSSARY, AND ABBREVIATIONS

These references, glossary, and abbreviations were used in the preparation of the Main Report, Environmental Impact Statement, and Appendixes.

Further references are to be found after the Economic, Environmental, and Social appendixes.

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47. Lake Erie-Lake Ontario Waterway Study, October 1973, U.S. Army Corps of Engineers, Buffalo District.

48. Summary Report- Great Lakes Simulation Studies, Volume 1 - November 1972, Volume 3 - December 1973, Pennsylvania State University under contract to U.S. Army Corps of Engineers, North Central Division.

49. Great Lakes Water Levels Studies - Main report entitled Regulation of the Great Lakes Water Levels, December 1973, and seven appendixes, International Joint Commission.

50. Plan of Study, Great Lakes Connecting Channels and Harbors Study, U.S. Army Corps of Engineers, Detroit District, May 1978.

51. Great Lakes Basin Framework Study, 1975-1976, Great Lakes Basin Commission.

52. Plan of Study, St. Lawrence Seaway, Additional Locks and Other Navigation Improvements, U.S. Army Corps of Engineers, Buffalo District, June 1978.

## GLOSSARY

Advance Engineering and Design Funds (Preconstruction Planning Funds): Funds appropriated by Congress to formulate the authorized project plan and develop designs to the stage where construction funds can be utilized. Such advance design work normally includes development of the General Design Memorandum for the final designs; Master Plan for Recreational Development; real estate requirements; developing preliminary cost allocations where applicable and obtaining local assurances thereon; and the completion of plans and specifications on a major component of the project scheduled for construction in the first year.

Aids to Navigation: Devices external to a craft, designed to assist in determination of the position of the craft, a safe course, or to warn of dangers or obstructions. (Should not be confused with "Navigation Aids" - for definition see below.)

Air Bubbler: A device which uses air bubbles to entrain warmer bottom water and pump it to the surface to retard ice formation.

Anchor Ice: Ice that forms on solid objects below the water surface in a river or stream, as a result of water being supercooled (below 32°F) but not freezing due to the swift water velocity.

Annual Financial Cost: Sum of the annual equivalent of the investment cost, the annual operation and maintenance costs, and the annual equivalent of major replacement cost. (Includes interest during construction).

Authorization: House and Senate Public Works Committee resolution or specific legislation which provide the legal basis for conducting studies or constructing projects. The money necessary for accomplishing the work is not a part of the authorization, but must come from an appropriation by Congress.

Authorized Project: When the recommended plan is passed by Congress and signed by the President, it is said to be "authorized." Congress must approve funds, by a separate act, for studies which lead to a General Design Memorandum. Congress must provide funds, by still another act, for construction of a project.

Benefit-Cost Ratio: The arithmetic ratio of estimated average annual dollar benefits to average annual dollar costs, is the benefit-cost ratio. The relation of benefits to costs represents the economic justification of a project.

Benefits: Increases or gains, net of associated or induced costs, in the value of goods and services which result from conditions with the project as compared with conditions without the project. National economic

benefits include: (a) direct output increases, (b) use of unemployed or underemployed resources, and (c) increases in output resulting from external economies.

Brash Ice: Small fragments of lake, river, or sea ice less than two meters in diameter.

Break-up: The period in the history of a lake, river or sea ice cover when the ice layer is fragmented by wind and wave action and/or thinning by melting. Mid-winter storms can break up an ice cover; however, the term is commonly used for the disappearance of the ice cover in the spring.

Cake Ice: Blocks of broken ice of various sizes greater than two meters in diameter.

Compensating Works: Structures which help to maintain a desired river or lake stage to offset the effects of dredging, or structures which change the natural flow condition.

Consolidated Pack Ice: An ice cover formed by the packing and freezing together of ice floes, brash, sludge and slush.

Construction Funds: Funds appropriated for construction of an authorized project.

Cubic Feet Per Second (CFS): A unit expressing rates of discharge. One cubic foot (.0283636 cubic meter) per second is equal to the discharge of a stream of a rectangular cross section, one foot wide and one foot deep, flowing water an average velocity of one foot (.3048 meter) per second.

Demonstration Program: A program to demonstrate the practicability of extending the navigation season on the Great Lakes-St. Lawrence Seaway System. The program identifies operational, social, and environmental problems attending winter navigation and allows testing of possible solutions. Data collected under the program are being utilized in the Congressionally authorized navigation season extension Survey study. The Demonstration Program was initiated in 1970 and completed September 1979.

Disbenefits: Those negative impacts of a project, both quantifiable and non-quantifiable, including but not limited to monetary costs. These are entered on the cost side of the benefit-cost calculation, when quantifiable.

Economic Life: The period determined by the estimated point in time at which the combined effect of physical depreciation, obsolescence, changing requirements for project services, and time and discount allowances will cause the cost of continuing the project to exceed the greater than the amortization period, and may be equal to but is generally less than the physical life.

Environmental Quality: One of the planning objectives required by the Water Resources Council Principles and Standards to enhance the quality of the environmental by the management, conservation, preservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems.

Environmental Validation Report: An environmental report undertaken to validate the favorable or unfavorable nature of continuing a specific program or project. The report is prepared to assist in the decision making.

Fast Ice: An ice cover which remains in the position where it originally formed. It is found along coasts where it may be attached to the shore, or over shoals where it may be held in position by islands or grounded hummocks or ridges.

Feasibility Study (also referred to as Survey Study): These are studies generally undertaken for the purpose of determining feasibility of specific plans to solve water resource problems. In general, these are studies for decision-making purposes. They recommend the favorable or unfavorable nature of undertaking a specific program or project. The study presently being undertaken is for the navigation season extension on the Great Lakes-St. Lawrence Seaway System, beyond the normal 8 1/2 month season, into the winter months, and to determine the extent of Federal participation. The study will determine the economic justification, engineering practicability, and the institutional, environmental and social impacts of an extended navigation season, utilizing historical, currently available, and to be gathered data, most of which is being and has been collected under the Demonstration Program. Based upon the Survey study, Congress will determine the desirability of season extension and decide whether a Federally supported permanent extension to the navigation season is in the public interest.

Feature Design Memoranda: A document generally prepared for each major element of the project during the postauthorization stage following the approval of the Phase II General Design Memorandum. They are used to form the basis for preparation and approval of the more complex plans and specifications.

First Cost: The total project construction cost including costs of lands, relocations, engineering, design, administration, and supervision.

Fiscal Year: The Federal fiscal year commences 1 October of one year and ends 30 September of the succeeding year (viz., the Fiscal Year 1977 commenced on 1 October 1976). It is the budget year used for programming and funding.

Frazil Ice: Fine crystals of ice suspended in water, formed in super-cooled, turbulent waters.

Gross National Product: The total final market value of all goods and services produced by an economy in one year.

Habitat: The total of the environmental conditions which affect the life of plants and animals.

Hanging Ice Dam: Ice that layers beneath the water surface in a river or stream causing retardation to the normal flow of water.

Ice Boom: Generally, wooded logs secured together with cables and installed in the winter across river channels to retard the flow of ice, and not that of water.

Ice Bridge: Ice that arches or forms a bridge across a flowing river, generally in locations where velocities are less than 2.5 feet per second. This generally occurs in wide river or lake areas immediately upstream of a narrow river channel. An ice bridge may also form when a larger ice floe or several ice floes converge to form an ice cover across the channel.

Ice Control Structures: Structures installed in winter which help stabilize the natural ice field upstream, but does not significantly retard the flow of water past the structures (i.e. ice boom).

Ice Cover: A significant expanse of ice of any type and form on the surface of a body of water.

Ice Floes: Free-floating sheets of ice, usually at least several inches thick, on a stream, lake, or seas. The size of an ice floe can range in size from fragments two meters in diameter to vast floes several kilometers in diameter.

Ice Jam: In rivers, broken ice and slush tend to collect in areas where downstream movement is restricted and then compacts into layers many feet thick. This ice blockage can restrict flow and generally hinder winter navigation.

Ice Retardation: The reduction or retardation of the flow of a river due to ice cover.

Ice Ridges: The dynamic action of wind and current induced ice pressure can cause a rafting and ridging of the ice cover that can reach thicknesses as great as 30 feet (9m).

Interest and Amortization: The annual costs of interest and amortization utilized in cost allocations based on amortizing the project investment over a 50-year period, starting on the in-service dates.

Interest Rate: The interest rate to be used in determining interest during construction and annual interest charges is the current rate for Federal Water Resources Projects at the time of the estimate applicable to the period of construction.

In the Public Interest: A difficult concept considering all publics. However, an action which satisfied most publics with minimized adverse results might adequately be "in the public interest."

Investment: The first cost plus interest during construction.

Lake Ice: The columnar structure ice sheet resulting from the freezing of lake waters.

Lift Lock: A canal lock serving to lift a vessel from one reach of water to another such as from the downstream side to the upstream side of a navigation lock and dam.

Lock: An enclosed part of a canal, waterway, etc., equipped with gates so that the level of the water can be changed to raise or lower boats from one level to another.

Lock Operation: Locks fill and empty by gravity, with no pumps required to raise or lower the water level. To raise the water level, valves are opened above the upper gates and water flows into the lock through tunnels under both lock walls. This process is reversed to lower water in the lock. Valves are opened below the lower gates and water drains out of the lock through tunnels. Gates at both ends of the lock open and close electrically after the proper water level has been reached.

Low Water Datum (LWD): A standard reference elevation, unique for each Great Lake, to which all depths on hydrographic charts are referred.

Major Replacements: The major replacement costs are determined as the interest and amortization over a 50-year period on the present worth of the estimated future costs expected to be incurred during that period.

National Economic Development: One of the planning objectives required by the Water Resources Council Principles and Standards to enhance national economic development, by increasing the value of the nation's output of goods and services and improving national economic efficiency.

Navigation Aids: Any instrument, device, chart, message, etc., intended to assist in the navigation of the craft. (Should not be confused with "Aids to Navigation" - for definition see above.)

Net Benefits: The difference between average annual benefits obtainable through operation of a project and average annual cost of project.

Open Water: A relatively large area of ice-free navigable water in an ice-encumbered lake or sea. Characterized by less than 1/10 ice cover.

Pack Ice: A general term used to include any form of floating ice other than fast ice regardless of its form or concentration.

Pancake Ice: Circular flat pieces of ice with a raised rim; the shape and rim are due to drifting and repeated collisions with other ice floes.

Phase I, General Design Memorandum (GDM): The first step of the post-authorization stage (Phase I). Bridges the gap between the time when a survey report is completed and authorized, and the initiation of detailed engineering and design (Phase II) of the authorized plan. Seeks to identify, assess and evaluate changes that may occur in order that a reformulation of the authorized plan may be made where these changes are significant, before proceeding in the Phase II GDM stage.

Phase II, General Design Memorandum (GDM): The document prepared during the second step of the post-authorization stage and prepared after approval of the Phase I, GDM. Should be primarily a functional design document concerned with the engineering of the structures necessary to achieve the project formulated in Phase I stage.

Phase I Studies: Studies made during the preparation of the Phase I General Design Memorandum document which seek to identify, assess and evaluate changes that may occur during the first step of the post-authorization stage.

Phase II Studies: Principally detailed engineering and design studies done during the preparation of the Phase II General Design Memorandum document.

Pile Dike: A dike constructed of posts or similar piling driven into the soil.

Poisson Distribution: A frequency distribution which approximates the binomial distribution when the probability of success in a single trial is very small and the number of trials is very large.

Postauthorization Studies: Planning and design that is accomplished after the project is authorized. Includes the Phase I and II General Design Memorandum documents and the Feature Design Memoranda, if necessary.

Preauthorization Studies: Feasibility studies made prior to and leading to authorization of a project. Survey and review reports sometimes cover more than one project, in which case the cost of preauthorization studies for a given project would be the portion of the study cost allocable to that specific project. (See Feasibility Study)

Preconstruction Planning: That planning work on an authorized project necessary to advance the project to the stage where the first major construction contract may be advertised after construction funds are appropriated. Is the same as post-authorization studies.

Primary Benefits: The identifiable net values of the goods or services resulting directly from the project. They are obtained by deducting from the gross benefits all cost of realization, except the economic costs of the project. Examples of primary benefits are the net savings in transportation costs, the flood or other damages prevented, increased land utilization, recreation benefits, and the net value of power produced.

Principles and Standards: Short title for "Establishment of Principles and Standards for Planning Water and Related Land Resources," which was published in the September 10, 1973 Federal Register. The Water Resources Planning Act (PL 89-80).

Secondary Benefits: These benefits usually include improved economic and business conditions and returns outside of immediate project influence.

Shore Ice: A stable ice sheet attached to the shoreline.

Sludge: An accumulation of soft ice mixed with slush.

Slush Ice: Compact accretion of snow frazil and ice particles projeced by wind and wave or ship action along the shore of lake or in long stretches of turbulent flow in rivers.

Socio-environmental Considerations: The consideration of the environment which is essential to the health and well-being of people.

Solid Blue Ice: Uniform and almost transparent ice formed in lakes and rivers, generally in low velocity areas.

Survey Studies: See "Feasibility Studies".

System: For the purposes of this document, each and every reference to the "Great Lakes-St. Lawrence Seaway System", "entire system", or "system", is intended to include all waterways that are or may be used or affected by vessels, navigation equipment, port facilities, and other resource commitments associated with year-round navigation. It is understood that the fundamental purview of this document is limited to waters under United States' jurisdiction unless further authority is granted through international agreement.

Young Ice: Newly formed ice with thickness from 5 to 15 centimeters.

Windrowed Ice: Ice that is layered or piled into ridges resulting from wind blowing over an ice field.

## ABBREVIATIONS

| | |
|---|---|
| AE & D | Advance Engineering and Design |
| ASCII | American National Standard Code for Information Interchange |
| B/C or B/C Ratio | Benefit/Cost Ratio |
| BEA | Bureau of Economic Analysis |
| BLS | Bureau of Labor Statistics |
| BOD | Biochemical Oxygen Demand |
| BOR | Bureau of Outdoor Recreation (NOW HCRS) |
| cfs | Cubic feet per second |
| CG | Coast Guard |
| COE | Corps of Engineers |
| CONRAIL | Consolidated Rail Corporation |
| CRREL | Cold Regions Research & Engineering Laboratory |
| CZM | Coastal Zone Management |
| DA | United States Department of the Army |
| DEIS | Draft Environmental Impact Statement |
| DOC | United States Department of Commerce |
| DOD | United States Department of Defense |
| DOI | United States Department of Interior |
| DOS | United States Department of State |
| DOT | United States Department of Transportation |
| EA | Environmental Assessment |
| EAGLE | Environmental Assessment of the Great Lakes Ecosystem |
| EIS | Environmental Impact Statement |
| ES | Environmental Statement |
| EPA | Environmental Protection Agency |
| EQ | Environmental Quality |
| EPIRB | Emergency Position Indicating Radio Beacon |
| EPOA | Environmental Plan of Action |
| EPOS | Environmental Plan of Study |

## ABBREVIATIONS (Cont.)

| | |
|---|---|
| ERDA | Energy Research & Development Agency |
| FERC | Federal Energy Regulatory Commission |
| FORTRAN | Formula Translation |
| FPC | Federal Power Commission (NOW FERC) |
| fps | Feet per second |
| F&WS | Fish and Wildlife Service |
| GDM | General Design Memorandum |
| GLBC | Great Lakes Basin Commission |
| GLC | Great Lakes Commission |
| GLERL | Great Lakes Environmental Research Laboratory |
| GLIMS | Great Lakes Information Management System |
| GL/SLS | Great Lakes-St. Lawrence Seaway |
| GNP | Gross National Product |
| HCRS | Heritage Conservation and Recreation Service (Previously Bureau of Outdoor Recreation) |
| ICC | Interstate Commerce Commission |
| IGLD | International Great Lakes Datum |
| IGLLB | International Great Lakes Levels Board |
| IJC | International Joint Commission |
| INC | Ice Navigation Center |
| LNT | Lowest Normal Tide |
| LORAN-C | Long Range Navigation |
| LWD | Low Water Datum |
| MARAD | Maritime Administration |
| MDNR | Michigan Department of Natural Resources |
| MSD | Marine Sanitation Device |
| NASA | National Aeronautics and Space Administration |
| NED | National Economic Development |
| NEPA | National Environmental Policy Act |
| NOAA | National Oceanic and Atmospheric Administration |
| NYDEC | New York Department of Environmental Conservation |

## ABBREVIATIONS (Cont.)

| | |
|---|---|
| O & M | Operation & Maintenance |
| OBERS | Office of Business Economics/Economic Research Service |
| OCE | Office of the Chief of Engineers |
| OMB | Office of Management and Budget |
| PASNY | Power Authority of the State of New York |
| PAWNS | Precise All-Weather Navigation System |
| P.L. | Public Law |
| RACONS | Radar Transponder Beacons |
| RD | Regional Development |
| RDEIS | Revised Draft Environmental Impact Statement |
| RRT | Regional Response Teams |
| R/T | Radio Telephone |
| SLAR | Side Looking Airborne Radar |
| SLSA | St. Lawrence Seaway Authority of Canada |
| SLSDC | St. Lawrence Seaway Development Corporation |
| SMSA | Standard Metropolitan Statistical Area |
| SS | Suspended Solids |
| SWB | Social Well Being |
| TCFS | Thousand Cubic feet per second |
| TP | Total Phosphorus |
| USC | United States Code |
| USDA | United States Department of Agriculture |
| WNB | Winter Navigation Board |
| WNRNW | Winter Navigation Research Needs Workshop |
| WRC | Water Resources Council |



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